FIG. 1A

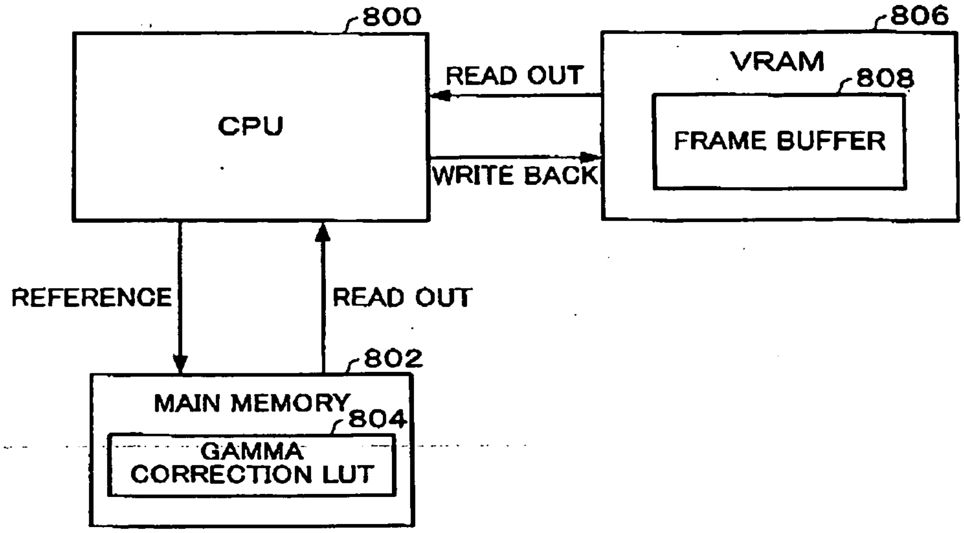

800
CPU
806
VRAM
808
FRAME BUFFER
READ OUT
WRITE BACK
REFERENCE
READ OUT
802
MAIN MEMORY
804
GAMMA CORRECTION LUT

FIG. 1B

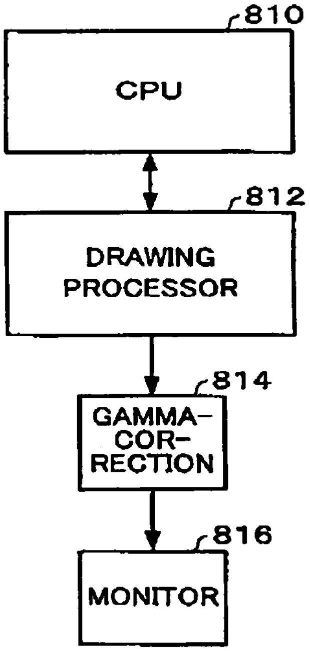

810
CPU
812
DRAWING PROCESSOR
814
GAMMA-COR-RECTION
816
MONITOR

FIG. 2

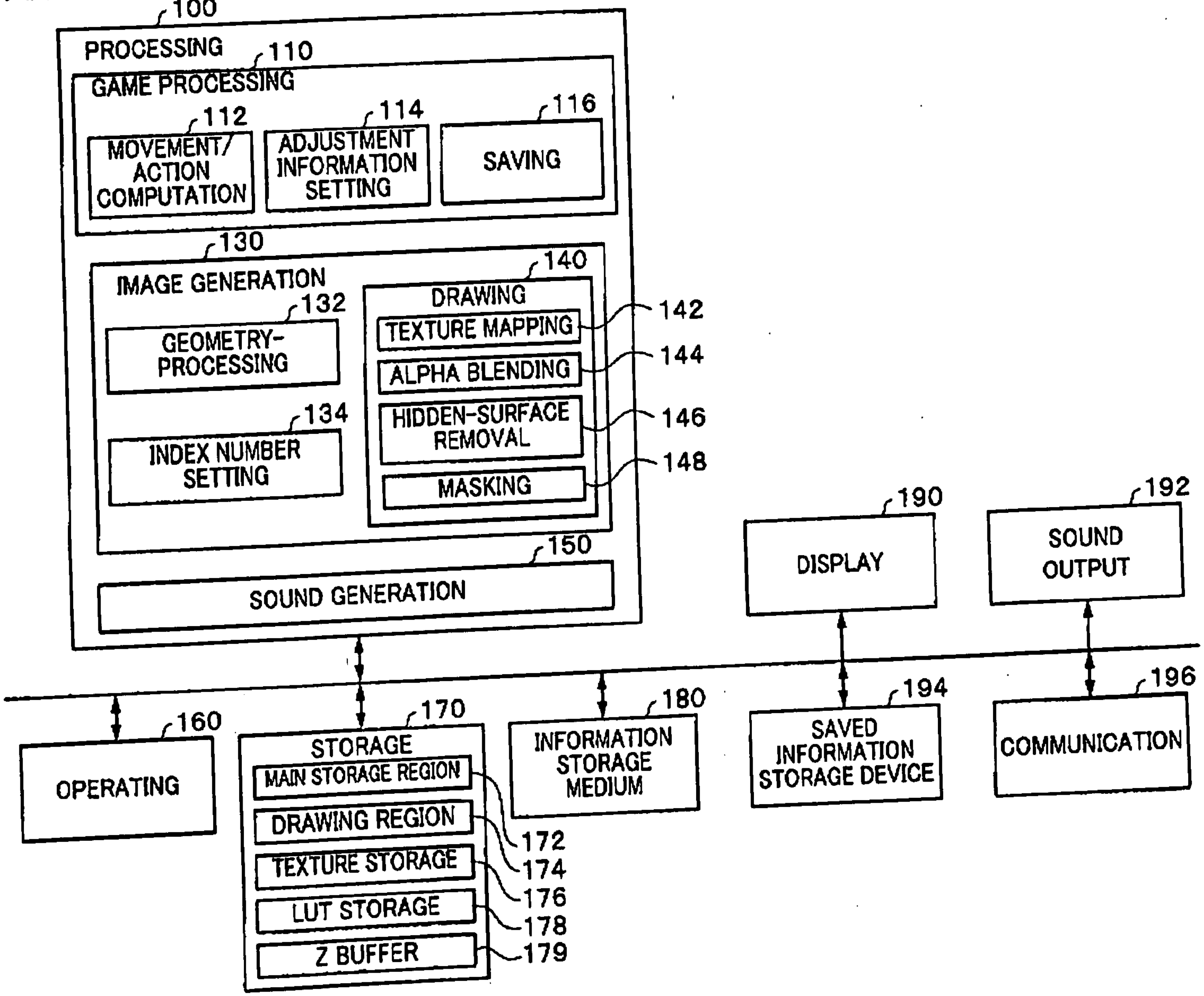
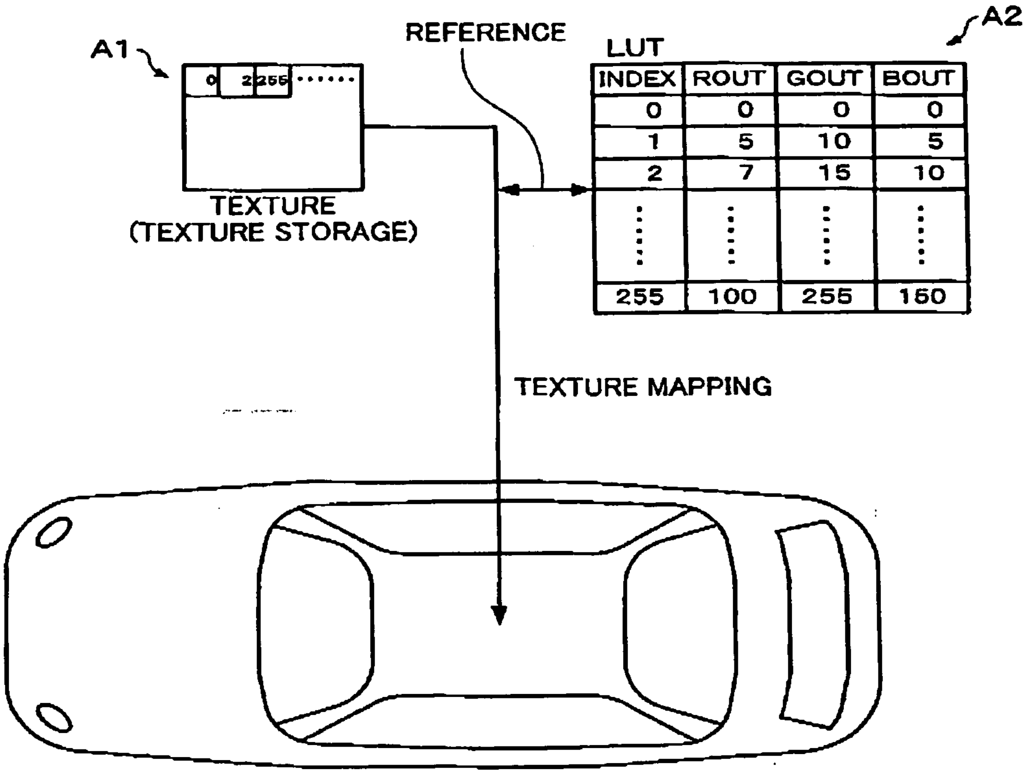

100
PROCESSING
110
GAME PROCESSING
112
MOVEMENT/ ACTION COMPUTATION
114
ADJUSTMENT INFORMATION SETTING
116
SAVING
130
IMAGE GENERATION
132
GEOMETRY-PROCESSING
134
INDEX NUMBER SETTING
140
DRAWING
TEXTURE MAPPING
ALPHA BLENDING
HIDDEN-SURFACE REMOVAL
MASKING
142
144
146
148
150
SOUND GENERATION
190
DISPLAY
192
SOUND OUTPUT
160
OPERATING
170
STORAGE
MAIN STORAGE REGION
DRAWING REGION
TEXTURE STORAGE
LUT STORAGE
Z BUFFER
172
174
176
178
179
180
INFORMATION STORAGE MEDIUM
194
SAVED INFORMATION STORAGE DEVICE
196
COMMUNICATION

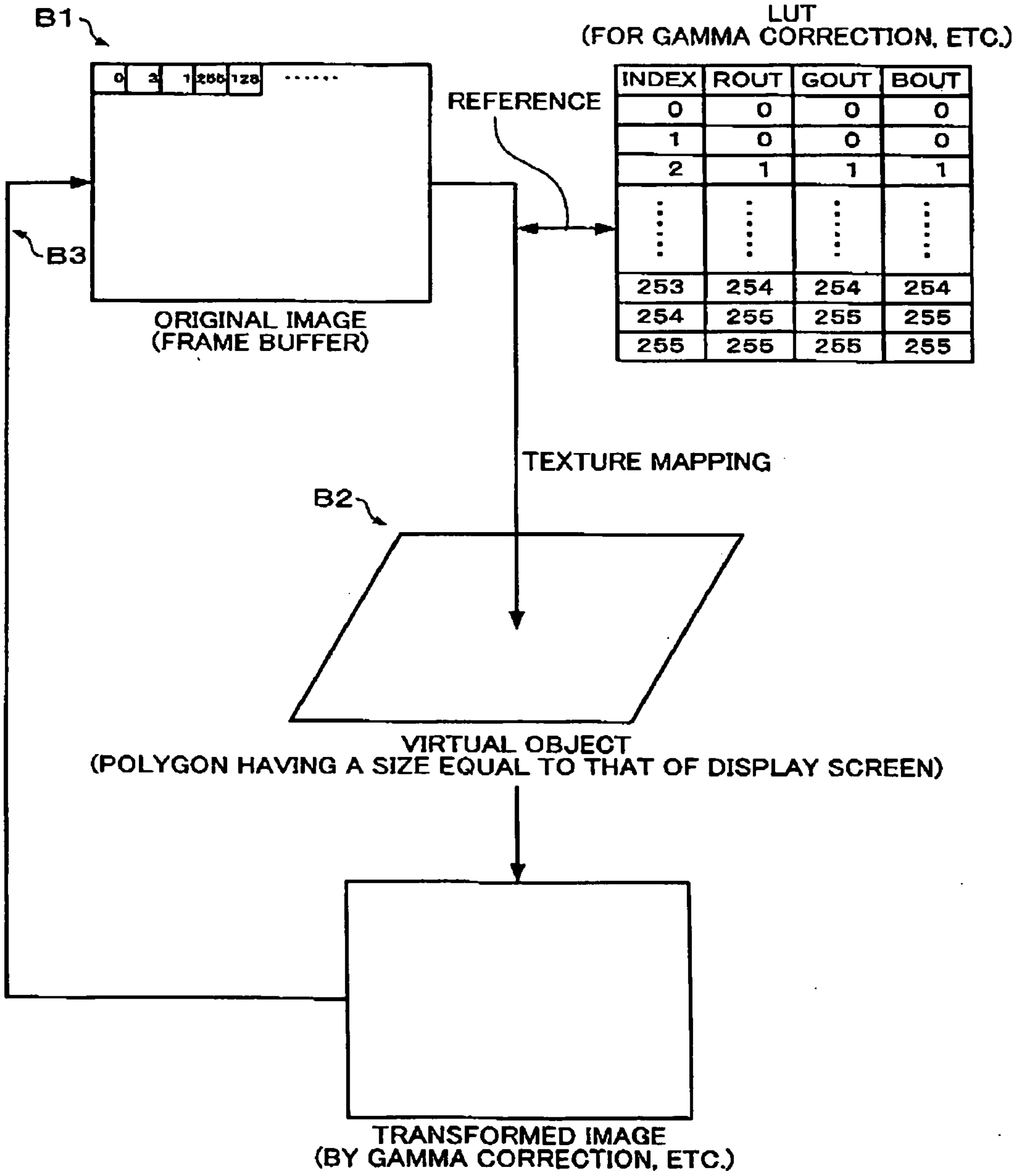
FIG. 3

INDEX COLOR TEXTURE-MAPPING


A1
0
2
255
TEXTURE
(TEXTURE STORAGE)
REFERENCE
LUT
A2
TEXTURE MAPPING

INDEX	ROUT	GOUT	BOUT
0	0	0	0
1	5	10	5
2	7	15	10
⋮	⋮	⋮	⋮
255	100	255	150

FIG. 4


B1
0
3
1
255
128
......
ORIGINAL IMAGE
(FRAME BUFFER)
REFERENCE
LUT
(FOR GAMMA CORRECTION, ETC.)
TEXTURE MAPPING
B2
VIRTUAL OBJECT
(POLYGON HAVING A SIZE EQUAL TO THAT OF DISPLAY SCREEN)
B3
TRANSFORMED IMAGE
(BY GAMMA CORRECTION, ETC.)

INDEX	ROUT	GOUT	BOUT
0	0	0	0
1	0	0	0
2	1	1	1
⋮	⋮	⋮	⋮
253	254	254	254
254	255	255	255
255	255	255	255

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FIG. 5A

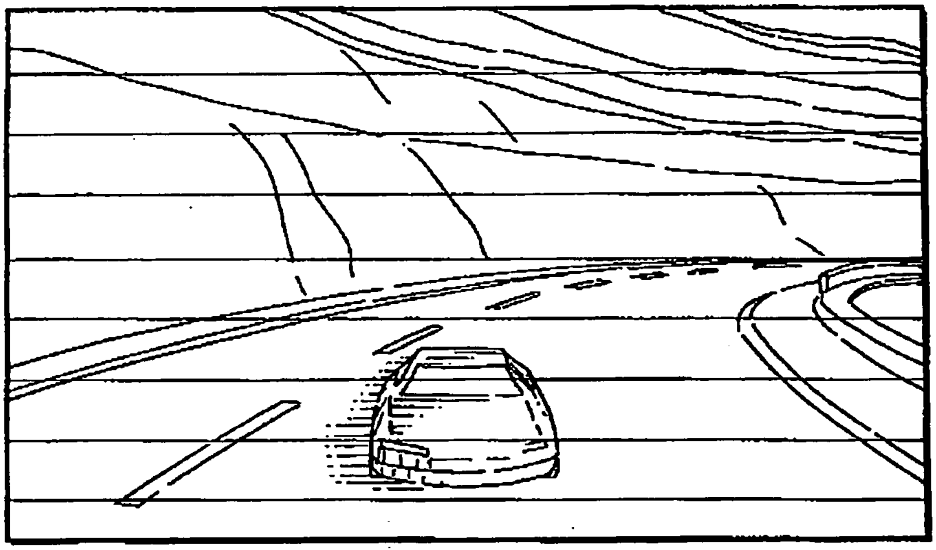

FIG. 5B

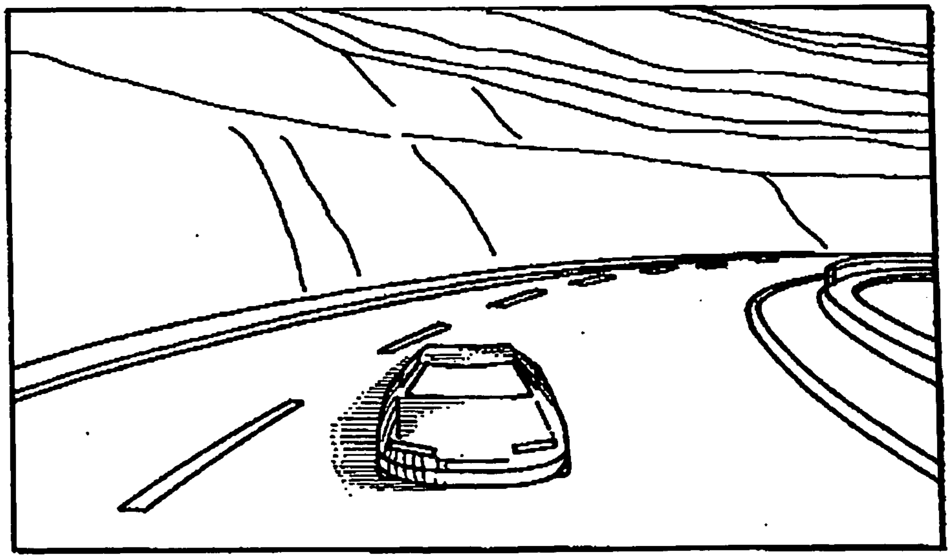

FIG. 6

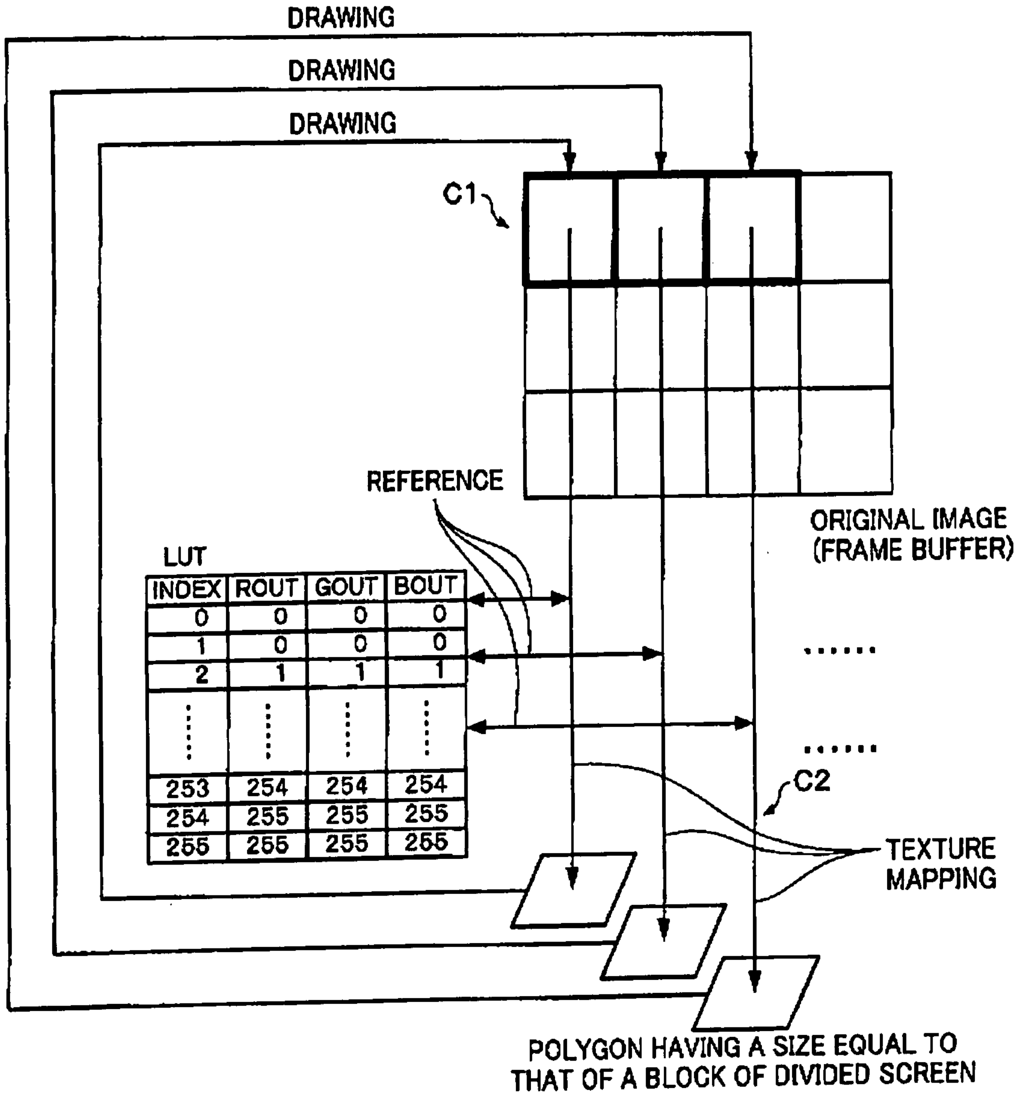
DRAWING
DRAWING
DRAWING
C1
REFERENCE
ORIGINAL IMAGE
(FRAME BUFFER)
LUT
INDEX ROUT GOUT BOUT
0 0 0 0
1 0 0 0
2 1 1 1
253 254 254 254
254 255 255 255
255 255 255 255
......
......
C2
TEXTURE
MAPPING
POLYGON HAVING A SIZE EQUAL TO
THAT OF A BLOCK OF DIVIDED SCREEN

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FIG. 7A

GAMMA CORRECTION

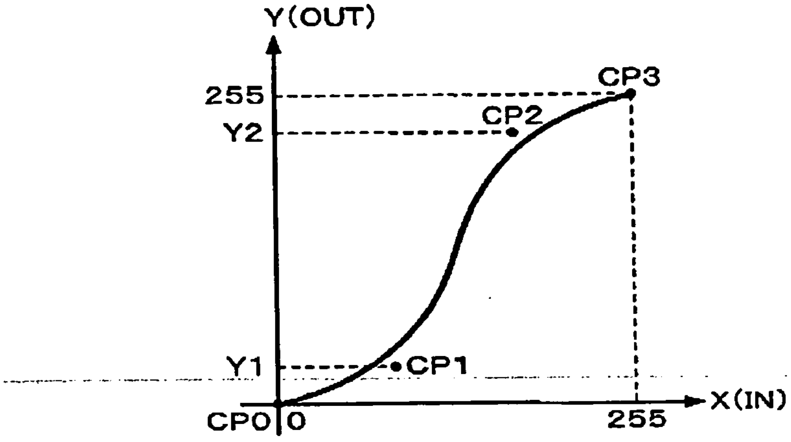

FIG. 7B

LUT FOR GAMMA CORRECTION

INDEX	ROUT	GOUT	BOUT
0	0	0	0
1	0	0	0
2	1	1	1
3	1	1	1
4	2	2	2
5	3	3	3
⋮	⋮	⋮	⋮
250	252	252	252
251	253	253	253
252	254	254	254
253	254	254	254
254	255	255	255
255	255	255	255

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FIG. 8A

NEGATIVE/POSITIVE INVERSION

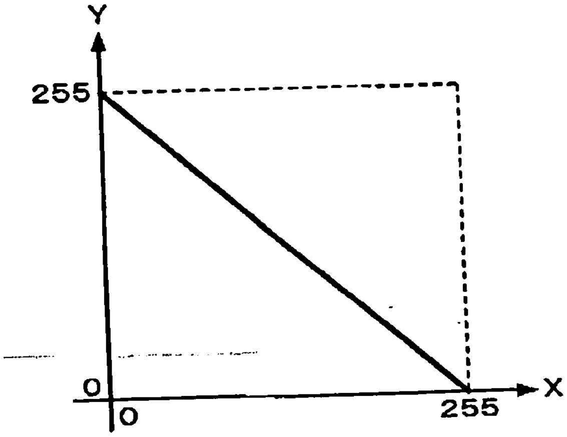

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FIG. 8B

LUT FOR NEGATIVE/POSITIVE INVERSION

INDEX	ROUT	GOUT	BOUT
0	255	255	255
1	254	254	254
2	253	253	253
3	252	252	252
⋮	⋮	⋮	⋮
253	2	2	2
254	1	1	1
255	0	0	0

FIG. 9A POSTERIZATION

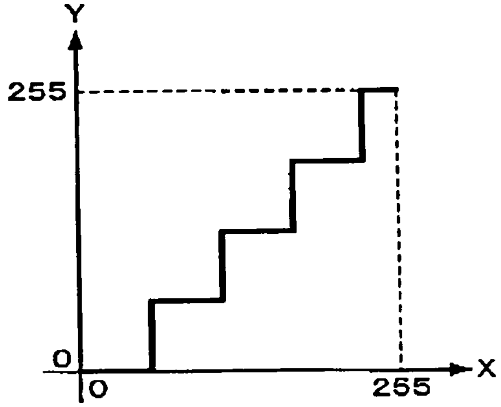

FIG. 9B SOLARIZATION

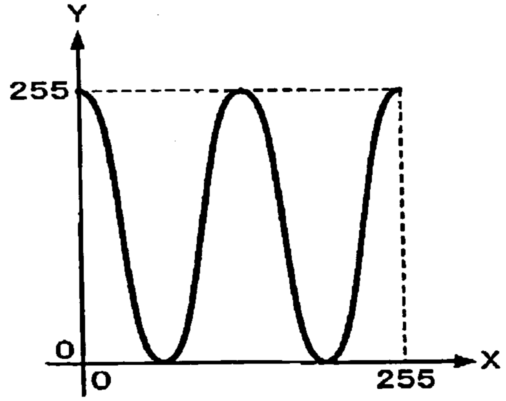

FIG. 9C BINARIZATION

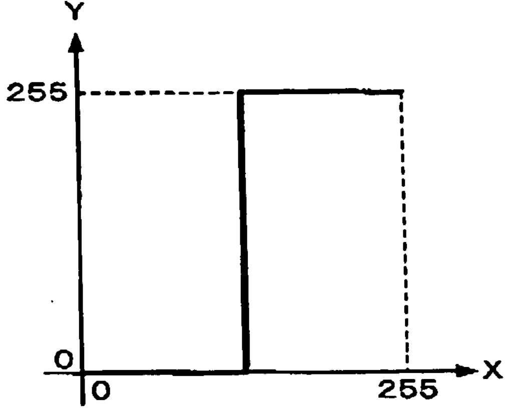

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FIG. 10A

LUTR FOR MONOTONE FILTERING

INDEX	ROUTR	GOUTR	BOUTR
0	0	0	0
1	0	0	0
2	0	0	0
3	0	0	0
4	1	1	1
5	1	1	1
⋮	⋮	⋮	⋮
250	74	74	74
251	75	75	75
252	75	75	75
253	75	75	75
254	75	75	75
255	76	76	76

FIG. 10B

LUTG FOR MONOTONE FILTERING

INDEX	ROUTG	GOUTG	BOUTG
0	0	0	0
1	0	0	0
2	1	1	1
3	1	1	1
4	2	2	2
5	2	2	2
⋮	⋮	⋮	⋮
250	146	146	146
251	147	147	147
252	147	147	147
253	148	148	148
254	148	148	148
255	149	149	149

FIG. 11

LUTB FOR MONOTONE FILTERING

INDEX	ROUTB	GOUTB	BOUTB
0	0	0	0
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
⋮	⋮	⋮	⋮
250	28	28	28
251	28	28	28
252	28	28	28
253	28	28	28
254	29	29	29
255	29	29	29

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FIG. 12

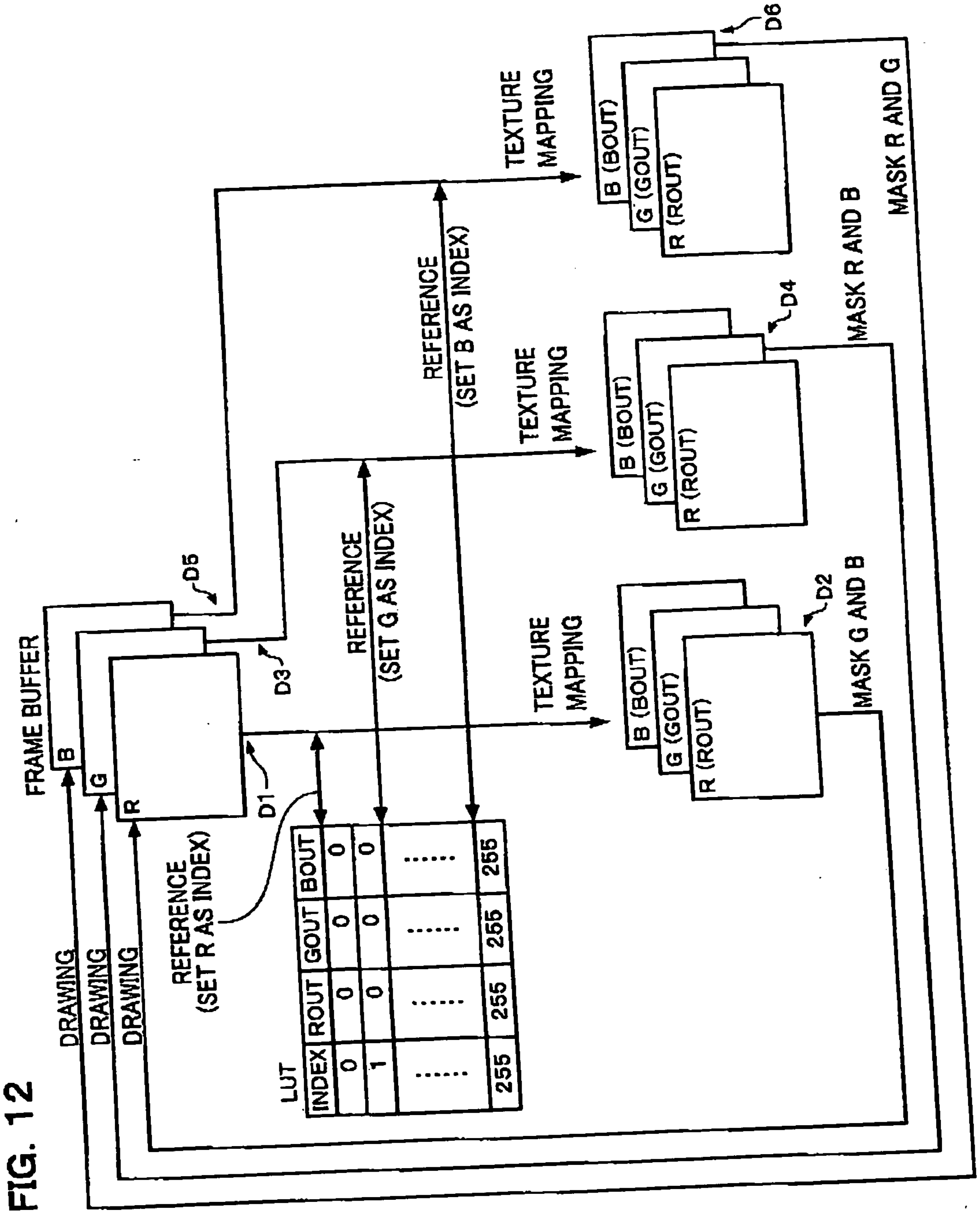
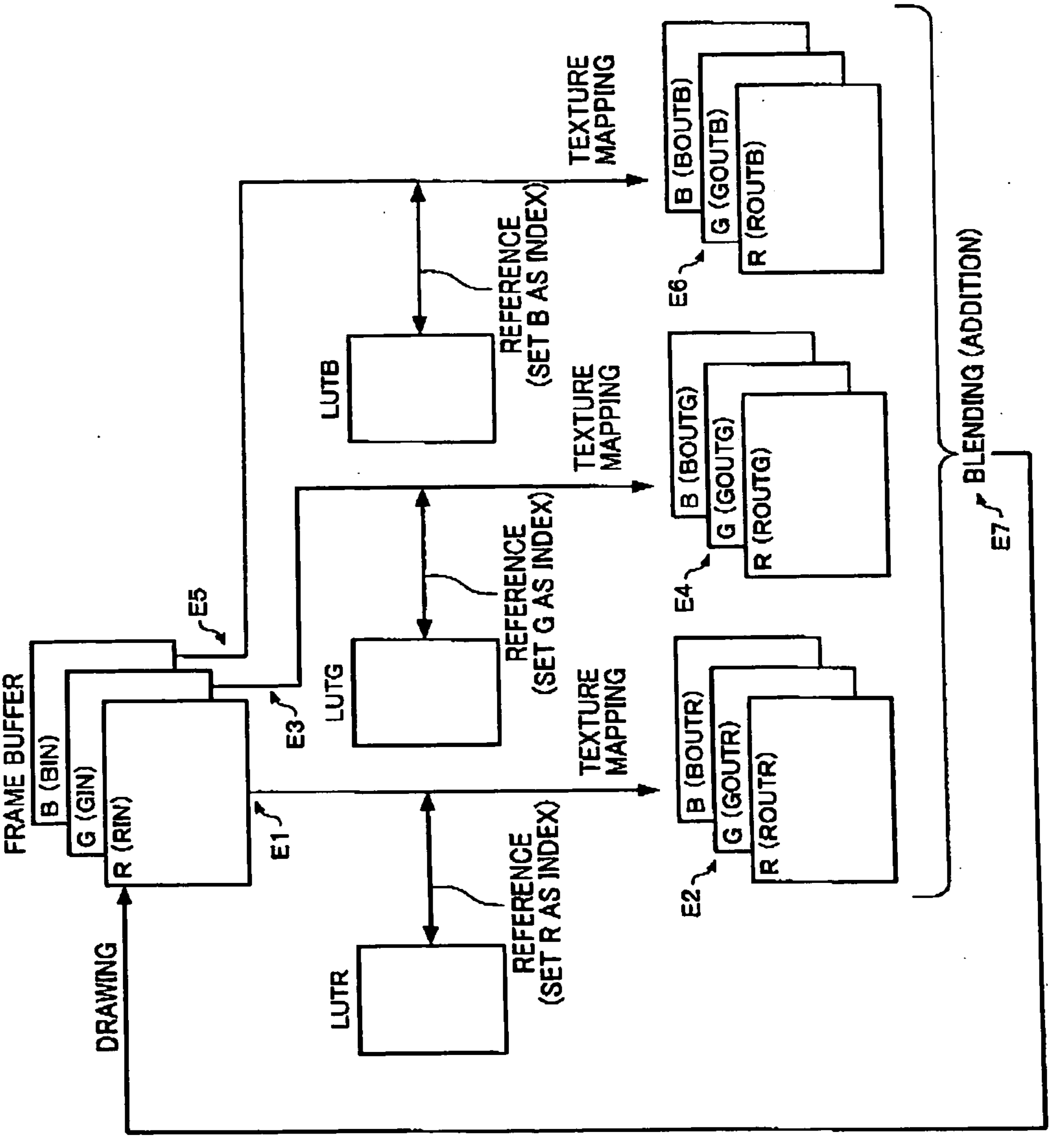

FRAME BUFFER
B
G
R
D1
D3
D5
DRAWING
DRAWING
DRAWING
REFERENCE (SET R AS INDEX)
REFERENCE (SET G AS INDEX)
REFERENCE (SET B AS INDEX)
LUT
INDEX | ROUT | GOUT | BOUT
0 | 0 | 0 | 0
1 | 0 | 0 | 0
...... | ...... | ...... | ......
255 | 255 | 255 | 255
TEXTURE MAPPING
TEXTURE MAPPING
TEXTURE MAPPING
B (BOUT)
G (GOUT)
R (ROUT)
D2
D4
D6
MASK G AND B
MASK R AND B
MASK R AND G

FIG. 13



FRAME BUFFER
B (BIN)
G (GIN)
R (RIN)
DRAWING
E1
E3
E5
LUTR
LUTG
LUTB
REFERENCE (SET R AS INDEX)
REFERENCE (SET G AS INDEX)
REFERENCE (SET B AS INDEX)
TEXTURE MAPPING
TEXTURE MAPPING
TEXTURE MAPPING
E2
B (BOUTR)
G (GOUTR)
R (ROUTR)
E4
B (BOUTG)
G (GOUTG)
R (ROUTG)
E6
B (BOUTB)
G (GOUTB)
R (ROUTB)
E7
BLENDING (ADDITION)

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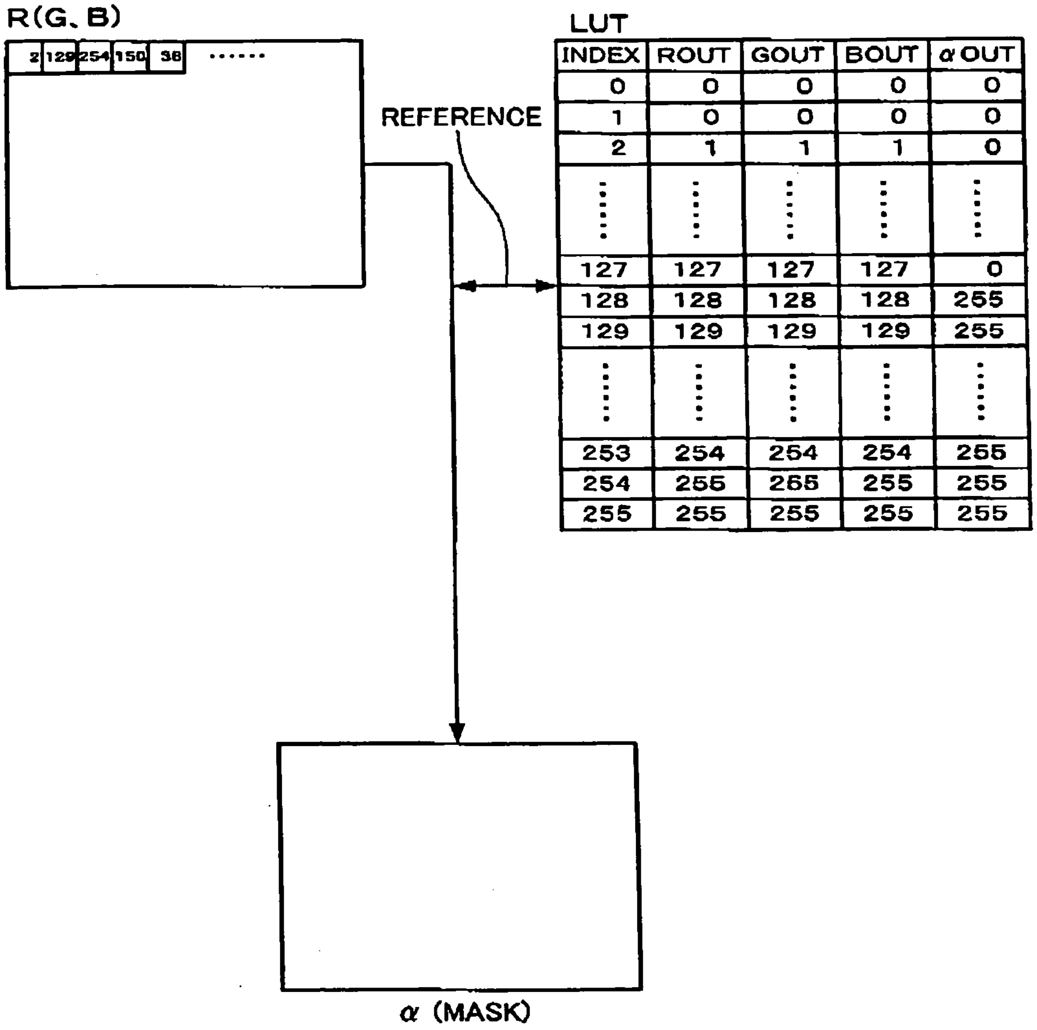
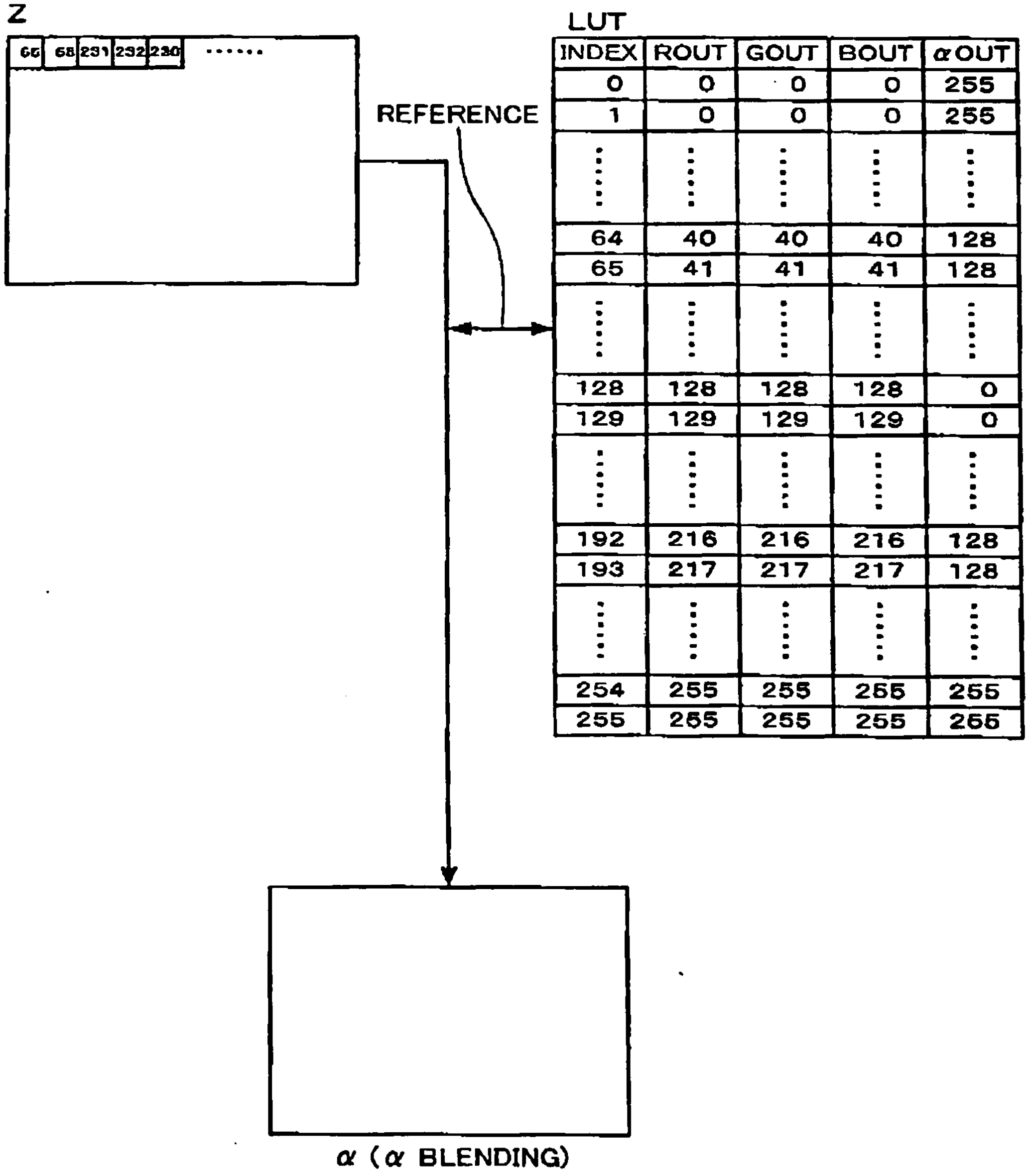
FIG. 14


R(G、B)
2
129
254
150
38
......
REFERENCE
LUT
α (MASK)

INDEX	ROUT	GOUT	BOUT	α OUT
0	0	0	0	0
1	0	0	0	0
2	1	1	1	0
⋮	⋮	⋮	⋮	⋮
127	127	127	127	0
128	128	128	128	255
129	129	129	129	255
⋮	⋮	⋮	⋮	⋮
253	254	254	254	255
254	255	255	255	255
255	255	255	255	255

FIG. 15


Z
66
68
231
232
230
....
REFERENCE
LUT
α (α BLENDING)

INDEX	ROUT	GOUT	BOUT	αOUT
0	0	0	0	255
1	0	0	0	255
⋮	⋮	⋮	⋮	⋮
64	40	40	40	128
65	41	41	41	128
⋮	⋮	⋮	⋮	⋮
128	128	128	128	0
129	129	129	129	0
⋮	⋮	⋮	⋮	⋮
192	216	216	216	128
193	217	217	217	128
⋮	⋮	⋮	⋮	⋮
254	255	255	255	255
255	255	255	255	255

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FIG. 16

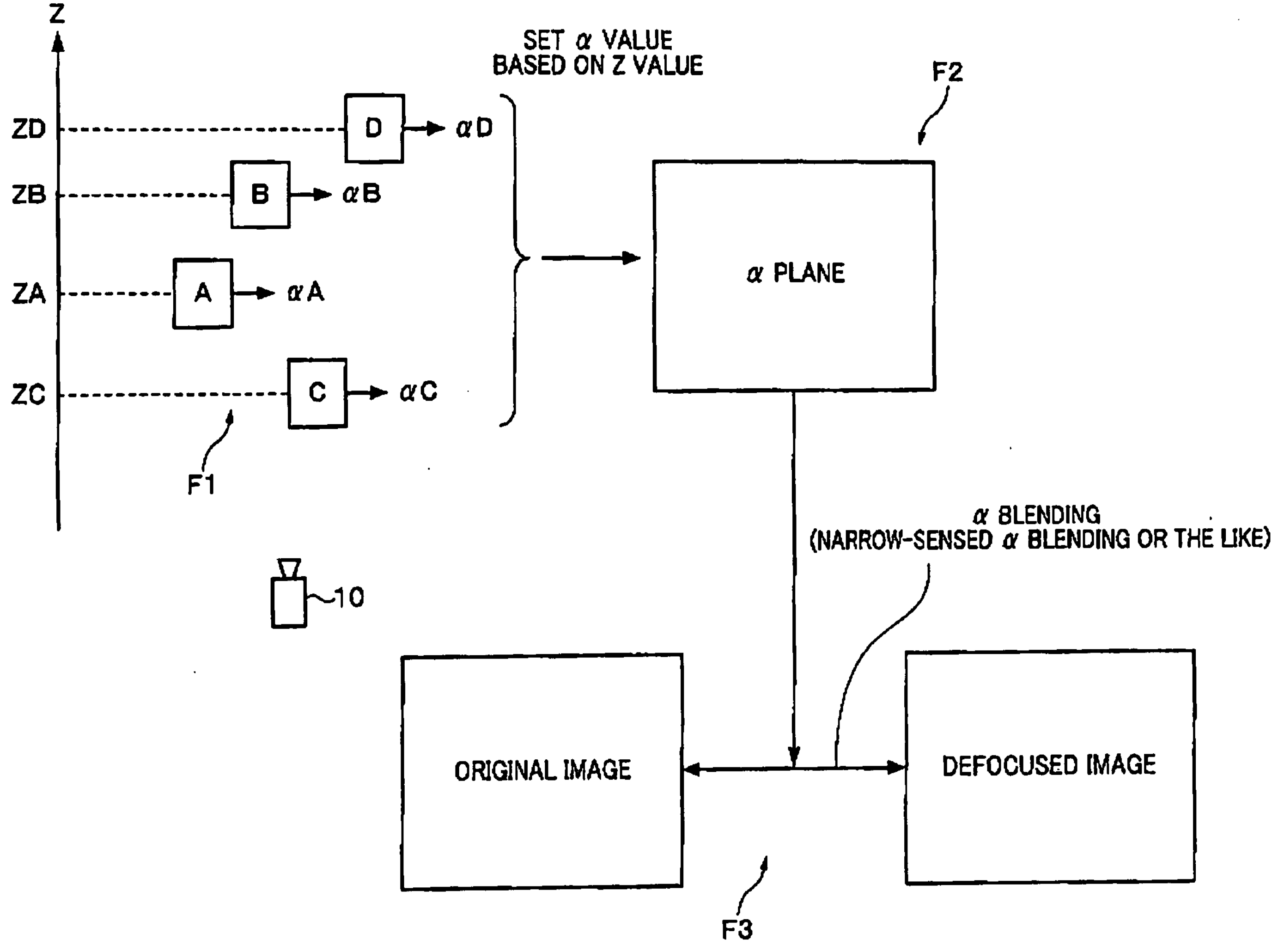
Z
ZD
ZB
ZA
ZC
D
B
A
C
αD
αB
αA
αC
F1
SET α VALUE
BASED ON Z VALUE
F2
α PLANE
α BLENDING
(NARROW-SENSED α BLENDING OR THE LIKE)
10
ORIGINAL IMAGE
DEFOCUSED IMAGE
F3

FIG. 17A ORIGINAL IMAGE

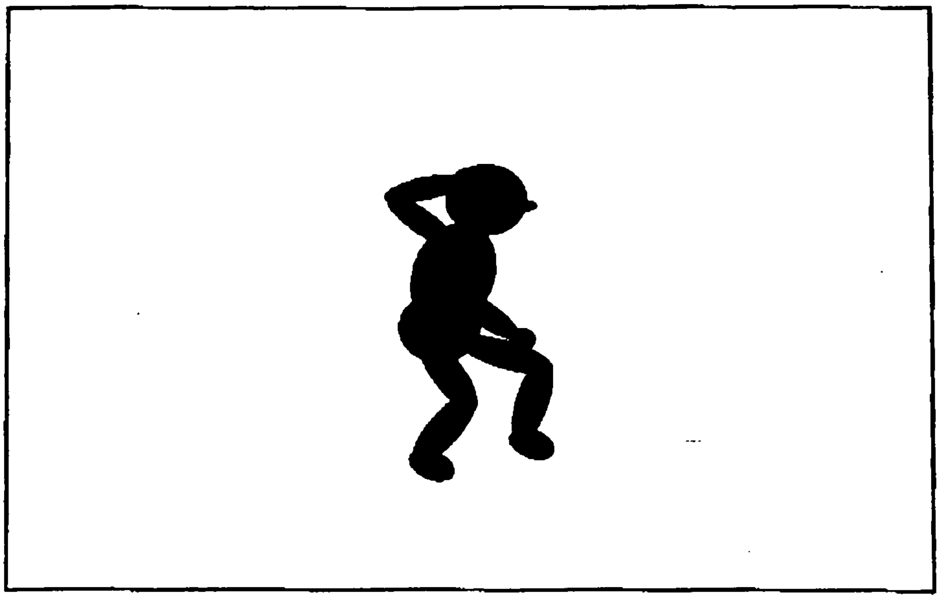

FIG. 17B DEFOCUSED IMAGE

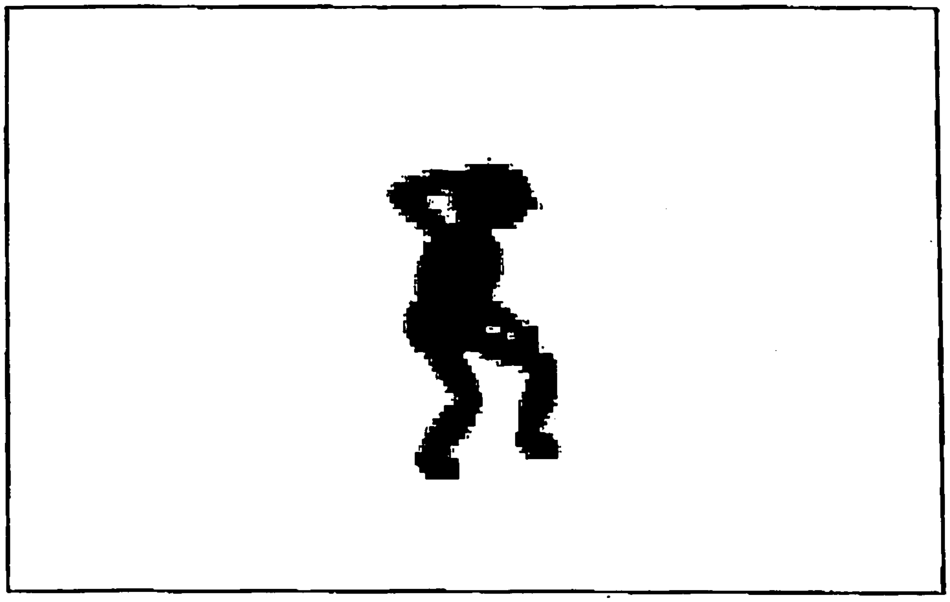

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FIG. 18

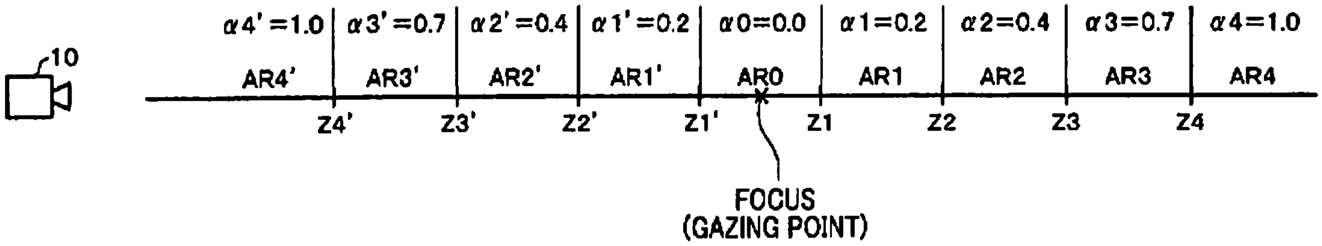
10
α4'=1.0
α3'=0.7
α2'=0.4
α1'=0.2
α0=0.0
α1=0.2
α2=0.4
α3=0.7
α4=1.0
AR4'
AR3'
AR2'
AR1'
AR0
AR1
AR2
AR3
AR4
Z4'
Z3'
Z2'
Z1'
Z1
Z2
Z3
Z4
FOCUS
(GAZING POINT)

FIG. 19A

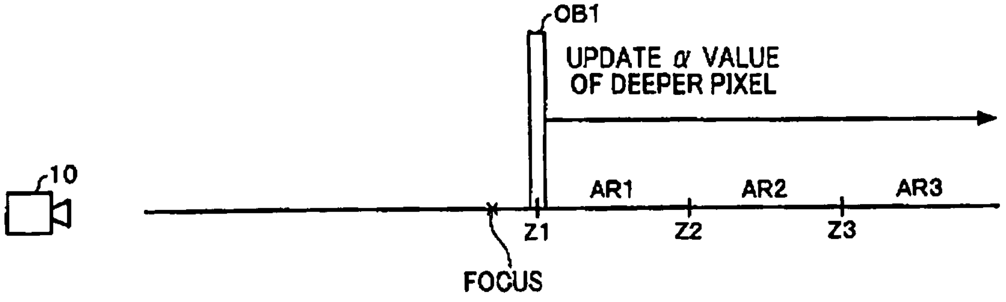
OB1
UPDATE α VALUE OF DEEPER PIXEL
10
AR1
AR2
AR3
Z1
Z2
Z3
FOCUS

FIG. 19B

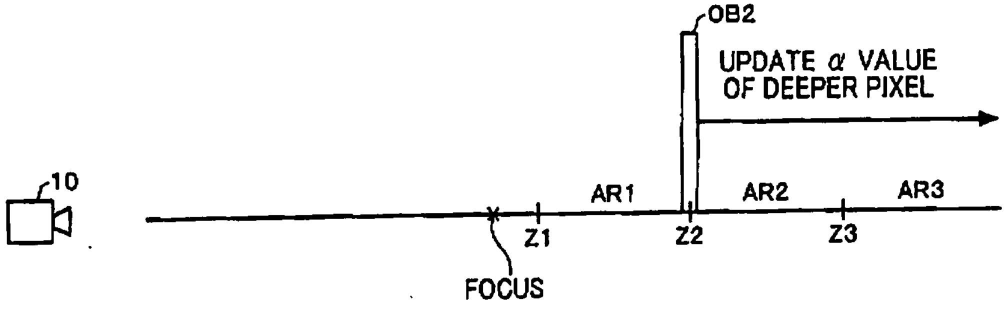
OB2
UPDATE α VALUE OF DEEPER PIXEL
10
AR1
AR2
AR3
Z1
Z2
Z3
FOCUS

FIG. 19C

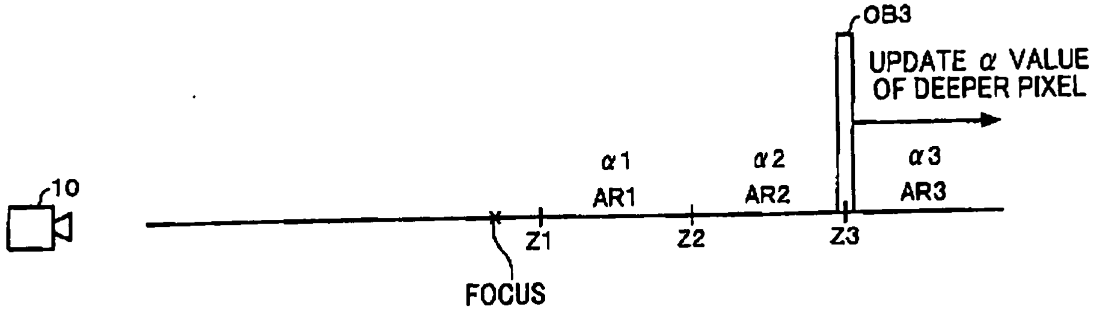
OB3
UPDATE α VALUE OF DEEPER PIXEL
10
α1
α2
α3
AR1
AR2
AR3
Z1
Z2
Z3
FOCUS

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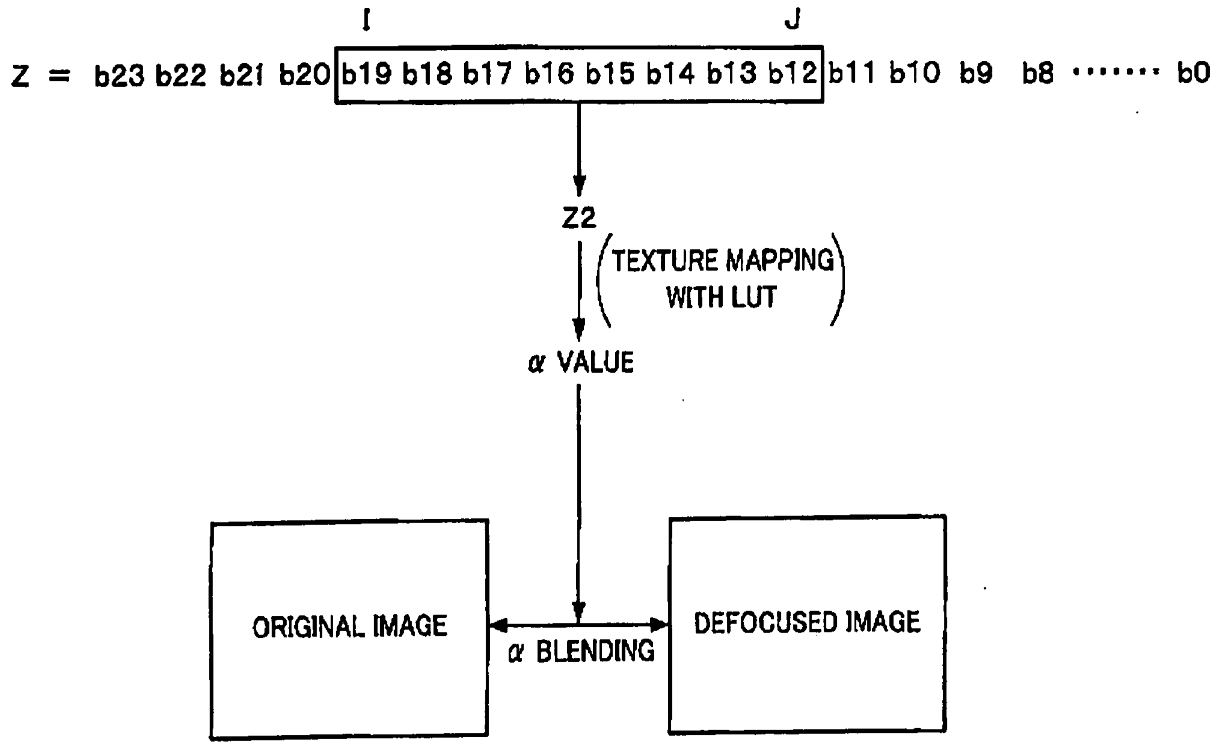
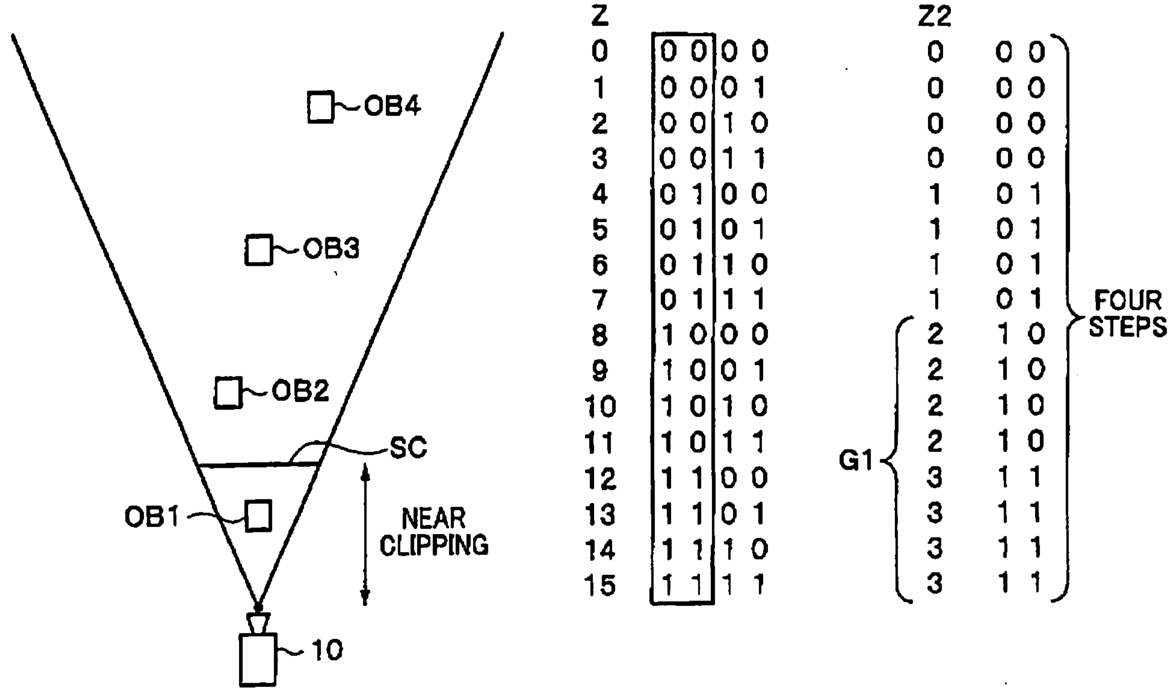
FIG. 20


I
J
Z = b23 b22 b21 b20 b19 b18 b17 b16 b15 b14 b13 b12 b11 b10 b9 b8 ······· b0
Z2
(TEXTURE MAPPING WITH LUT)
α VALUE
ORIGINAL IMAGE
α BLENDING
DEFOCUSED IMAGE

T08T0T" E9SZE660

FIG. 21


OB4
OB3
OB2
SC
OB1
NEAR CLIPPING
10
G1
FOUR STEPS

Z			Z2	
0	0 0	0 0	0	0 0
1	0 0	0 1	0	0 0
2	0 0	1 0	0	0 0
3	0 0	1 1	0	0 0
4	0 1	0 0	1	0 1
5	0 1	0 1	1	0 1
6	0 1	1 0	1	0 1
7	0 1	1 1	1	0 1
8	1 0	0 0	2	1 0
9	1 0	0 1	2	1 0
10	1 0	1 0	2	1 0
11	1 0	1 1	2	1 0
12	1 1	0 0	3	1 1
13	1 1	0 1	3	1 1
14	1 1	1 0	3	1 1
15	1 1	1 1	3	1 1

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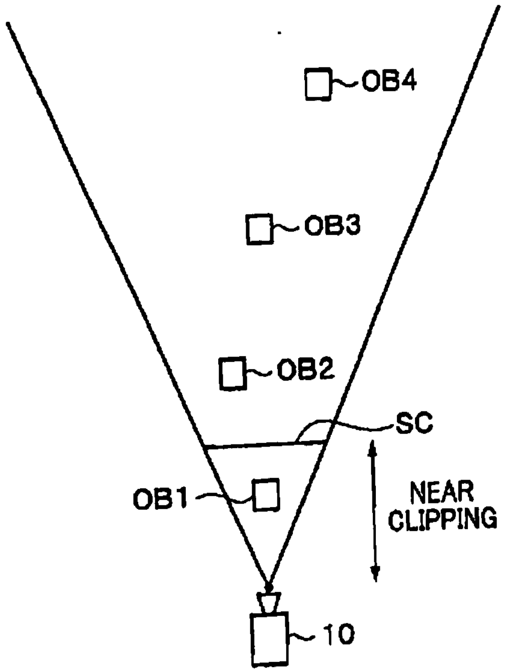
FIG. 22



OB4
OB3
OB2
SC
OB1
NEAR CLIPPING
10

Z					Z2			
0	0	0	0	0	0	0	0	FOUR STEPS
1	0	0	0	1	0	0	0	
2	0	0	1	0	1	0	1	
3	0	0	1	1	1	0	1	
4	0	1	0	0	2	1	0	
5	0	1	0	1	2	1	0	
6	0	1	1	0	3	1	1	
7	0	1	1	1	3	1	1	
8	1	0	0	0	3	1	1	CLAMPING
9	1	0	0	1	3	1	1	
10	1	0	1	0	3	1	1	
11	1	0	1	1	3	1	1	
12	1	1	0	0	3	1	1	
13	1	1	0	1	3	1	1	
14	1	1	1	0	3	1	1	
15	1	1	1	1	3	1	1	

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FIG. 23

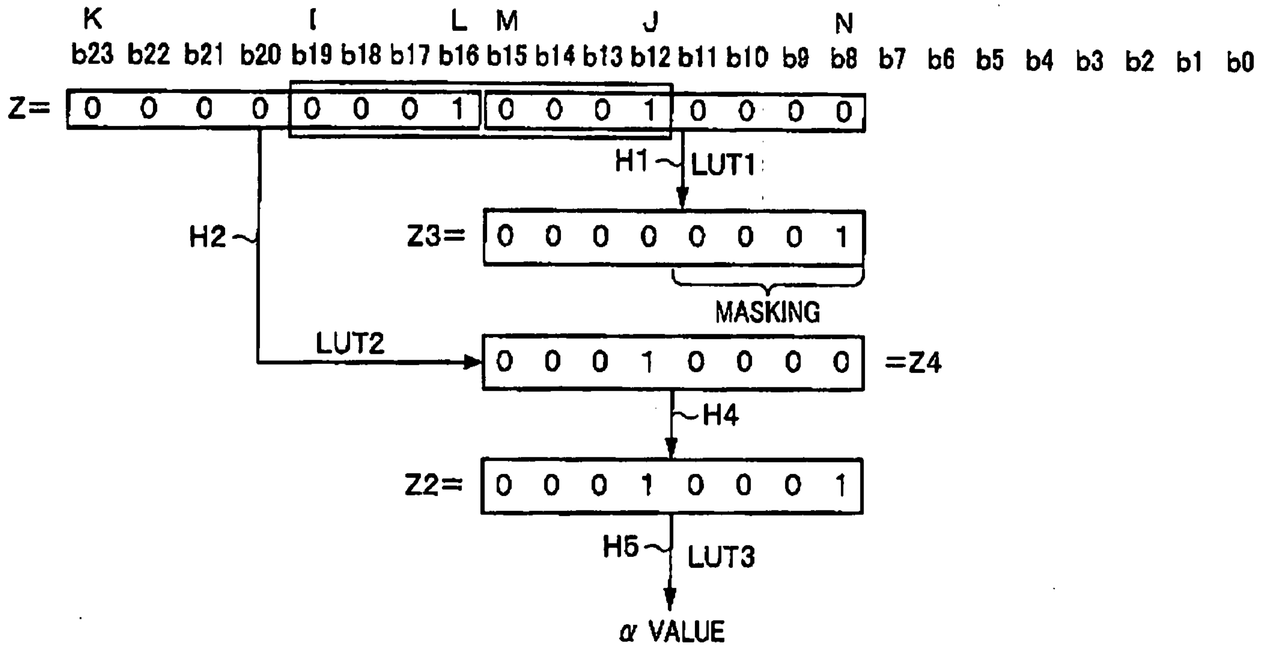
K
I
L
M
J
N
b23 b22 b21 b20 b19 b18 b17 b16 b15 b14 b13 b12 b11 b10 b9 b8 b7 b6 b5 b4 b3 b2 b1 b0
Z= 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0
H1
LUT1
Z3= 0 0 0 0 0 0 0 1
MASKING
H2
LUT2
0 0 0 1 0 0 0 0 =Z4
H4
Z2= 0 0 0 1 0 0 0 1
H5
LUT3
α VALUE

FIG. 24

LUT1 (BITS 15 TO 8)

INDEX	OUT (ANY ONE OF R, G, B AND α)
0x00 (00000000)	0x00 (00000000)
⋮	⋮
0x0F (00001111)	0x00 (00000000)
0x10 (00010000)	0x01 (00000001)
⋮	⋮
0x1F (00011111)	0x01 (00000001)
0x20 (00100000)	0x02 (00000010)
⋮	⋮
0x2F (00101111)	0x02 (00000010)
0x30 (00110000)	0x03 (00000011)
⋮	⋮
0xE0 (11100000)	0x0E (00001110)
⋮	⋮
0xEF (11101111)	0x0E (00001110)
0xF0 (11110000)	0x0F (00001111)
0xF1 (11110001)	0x0F (00001111)
0xF2 (11110010)	0x0F (00001111)
⋮	⋮
0xFF (11111111)	0x0F (00001111)

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FIG. 25

LUT2 (BITS 23 TO 16)

INDEX	OUT (ANY ONE OF R, G, B AND α)
0x00 (00000000)	0x00 (00000000)
0x01 (00000001)	0x10 (00010000)
0x02 (00000010)	0x20 (00100000)
0x03 (00000011)	0x30 (00110000)
0x04 (00000100)	0x40 (01000000)
⋮	⋮
0x0E (00001110)	0xE0 (11100000)
0x0F (00001111)	0xF0 (11110000)
0x10 (00010000)	0xF0 (11110000)
0x11 (00010001)	0xF0 (11110000)
⋮	⋮
0xFF (11111111)	0xF0 (11110000)

Q1

CLAMPING

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FIG. 26A

LUT3

INDEX	OUT(α)
0x00 (00000000)	0xFF (11111111)
0x01 (00000001)	0xFE (11111110)
0x02 (00000010)	0xFB (11111011)
⋮	⋮
0x7F (01111111)	0x00 (00000000)
0x80 (10000000)	0x00 (00000000)
0x81 (10000001)	0x00 (00000000)
⋮	⋮
0xFE (11111110)	0xFE (11111110)
0xFF (11111111)	0xFF (11111111)

FIG. 26B

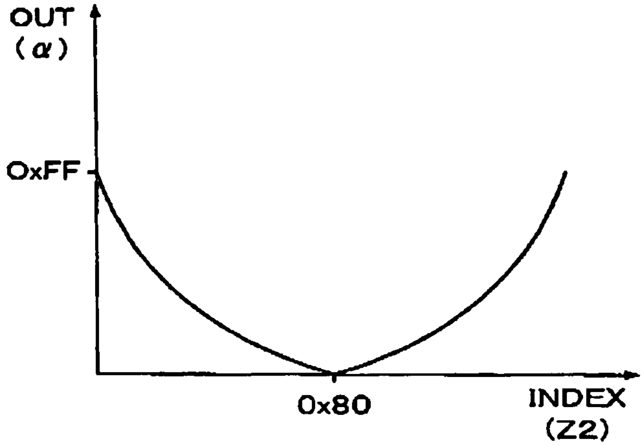


FIG. 27

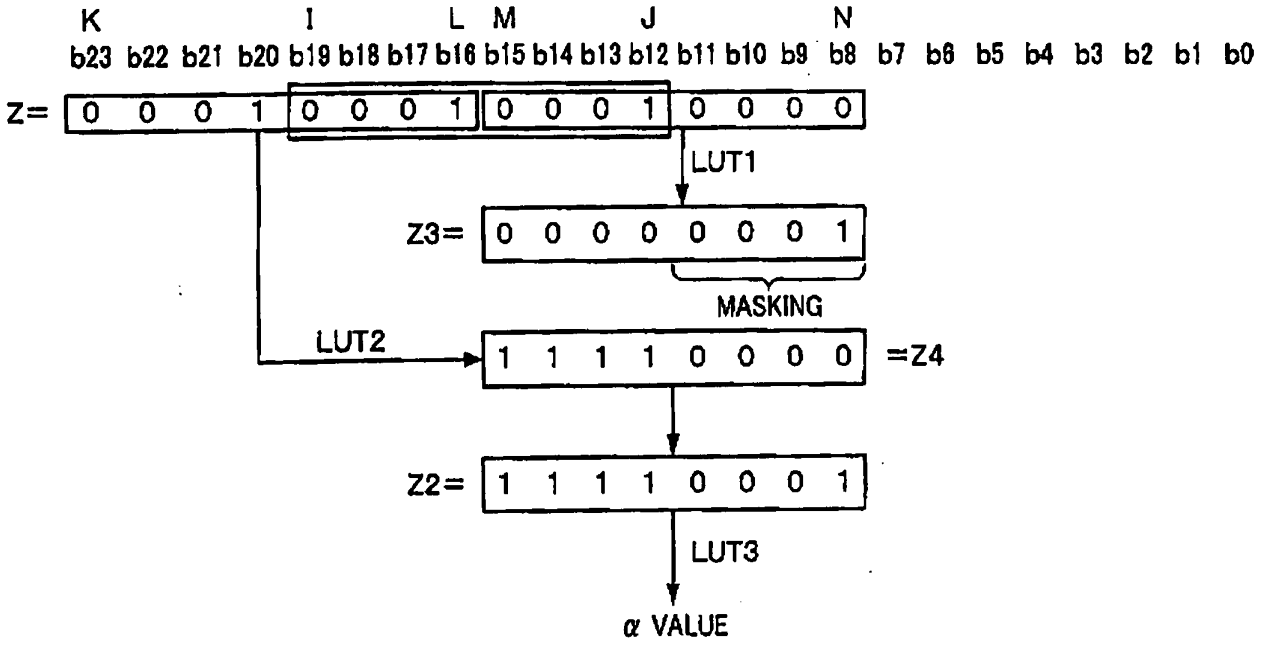
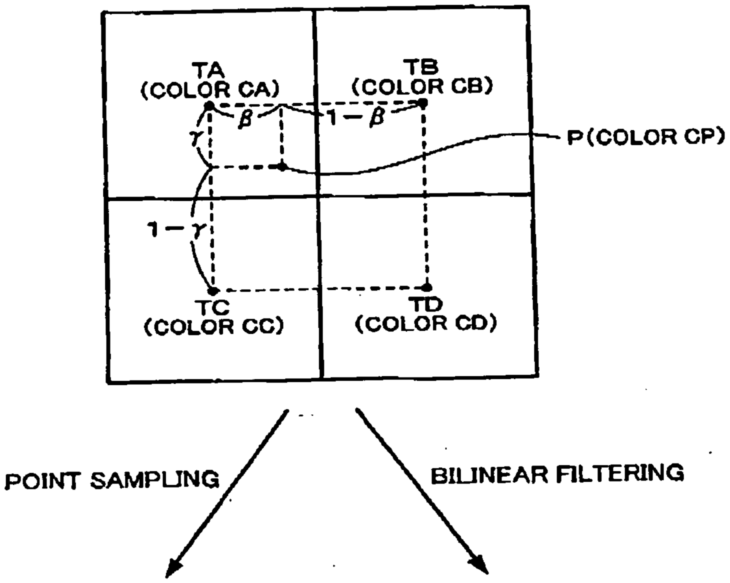

K
I
L
M
J
N
b23 b22 b21 b20 b19 b18 b17 b16 b15 b14 b13 b12 b11 b10 b9 b8 b7 b6 b5 b4 b3 b2 b1 b0
Z=
0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0
LUT1
Z3=
0 0 0 0 0 0 0 1
MASKING
LUT2
1 1 1 1 0 0 0 0
=Z4
Z2=
1 1 1 1 0 0 0 1
LUT3
α VALUE

FIG. 28


TA
(COLOR CA)
TB
(COLOR CB)
β
1−β
γ
1−γ
P(COLOR CP)
TC
(COLOR CC)
TD
(COLOR CD)
POINT SAMPLING
BILINEAR FILTERING

$CP=CA$

$$CP=(1-\beta)\times(1-\gamma)\times CA+\beta\times(1-\gamma)\times CB+(1-\beta)\times\gamma\times CC+\beta\times\gamma\times CD$$

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FIG. 29

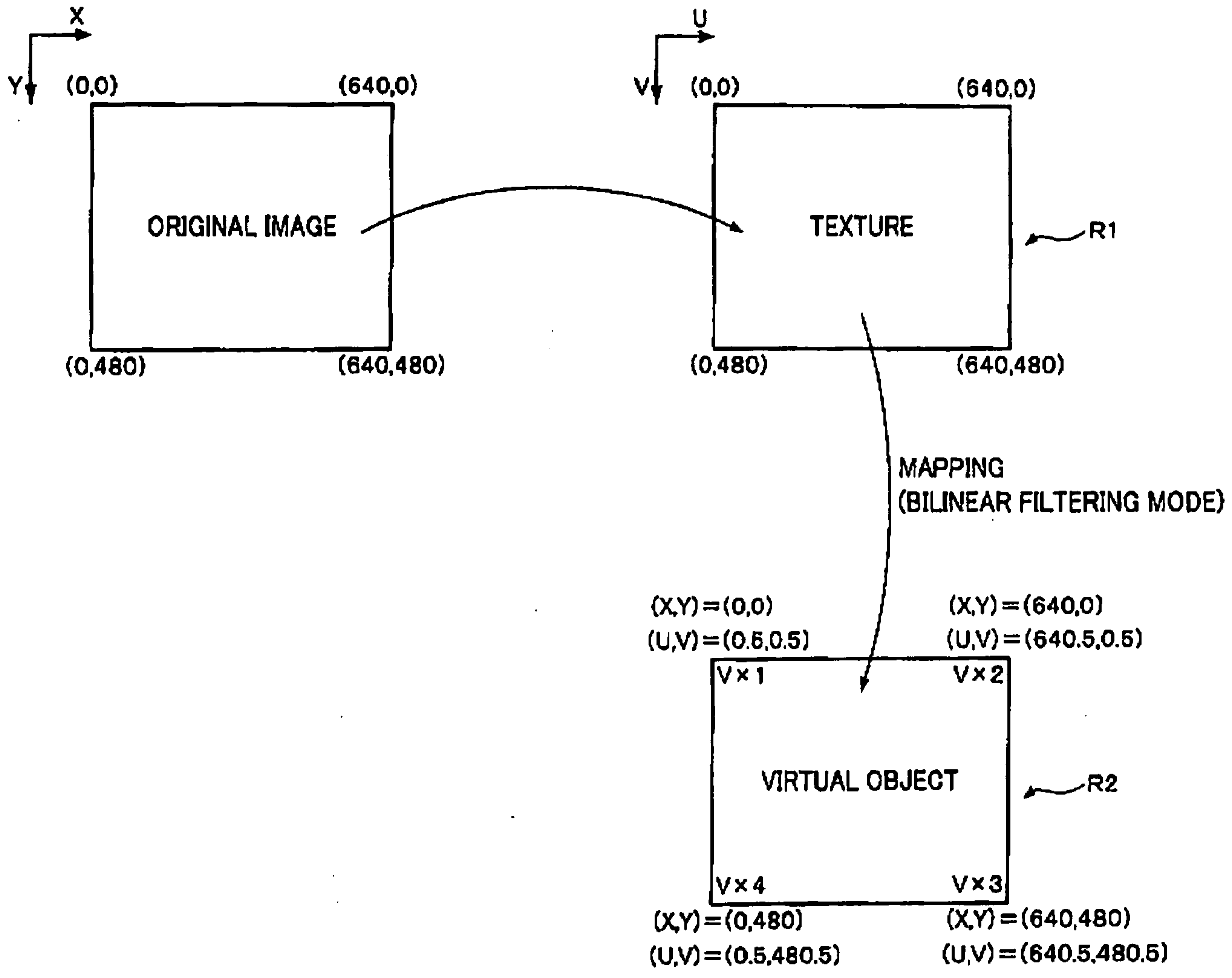
X
Y
(0,0)
(640,0)
ORIGINAL IMAGE
(0,480)
(640,480)
U
V
(0,0)
(640,0)
TEXTURE
R1
(0,480)
(640,480)
MAPPING
(BILINEAR FILTERING MODE)
(X,Y)=(0,0)
(U,V)=(0.5,0.5)
(X,Y)=(640,0)
(U,V)=(640.5,0.5)
V×1
V×2
VIRTUAL OBJECT
R2
V×4
V×3
(X,Y)=(0,480)
(U,V)=(0.5,480.5)
(X,Y)=(640,480)
(U,V)=(640.5,480.5)

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FIG. 30

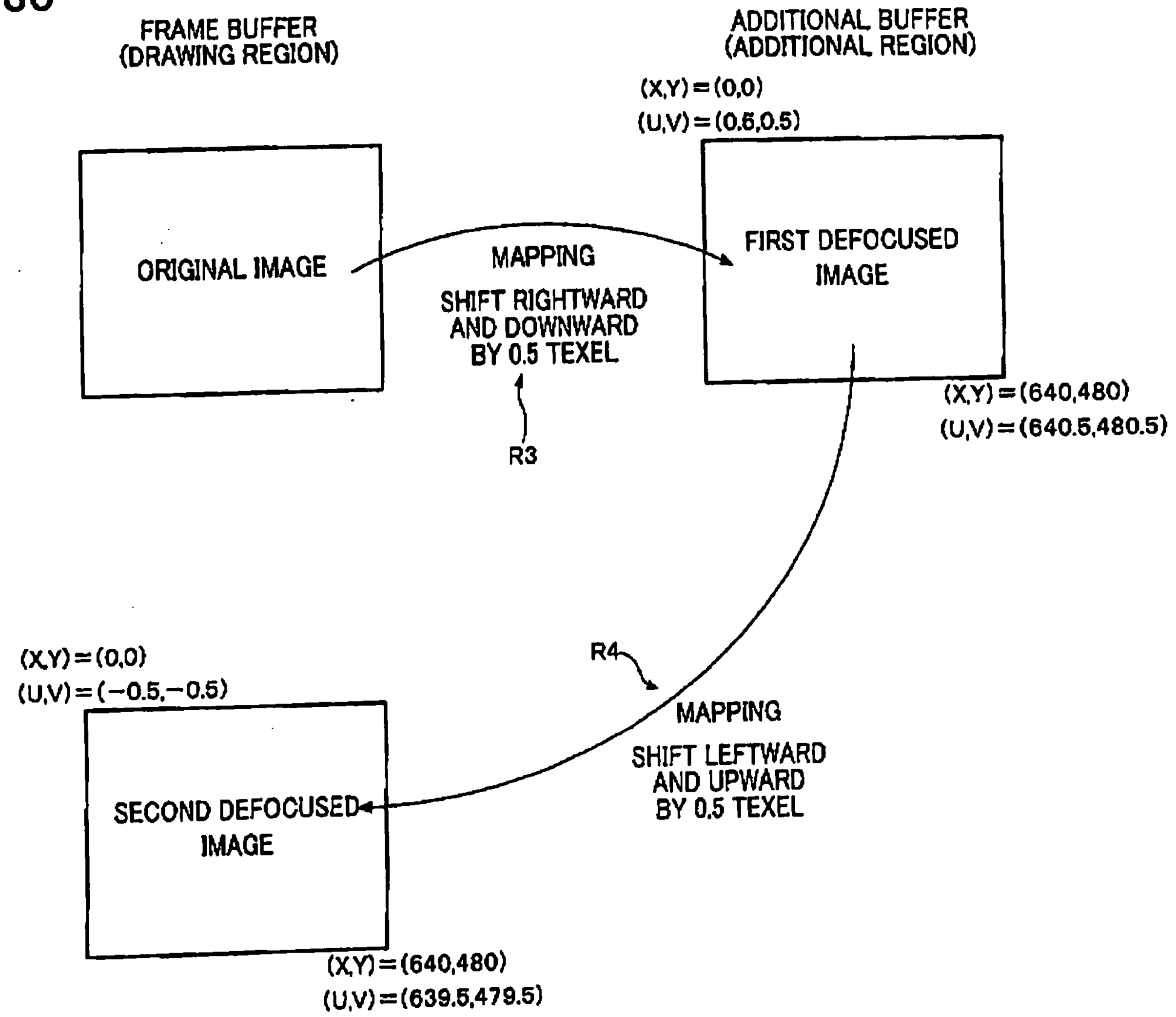
FRAME BUFFER
(DRAWING REGION)
ORIGINAL IMAGE
ADDITIONAL BUFFER
(ADDITIONAL REGION)
(X,Y)=(0,0)
(U,V)=(0.5,0.5)
FIRST DEFOCUSED IMAGE
(X,Y)=(640,480)
(U,V)=(640.5,480.5)
MAPPING
SHIFT RIGHTWARD AND DOWNWARD BY 0.5 TEXEL
R3
R4
MAPPING
SHIFT LEFTWARD AND UPWARD BY 0.5 TEXEL
(X,Y)=(0,0)
(U,V)=(−0.5,−0.5)
SECOND DEFOCUSED IMAGE
(X,Y)=(640,480)
(U,V)=(639.5,479.5)

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FIG. 31A

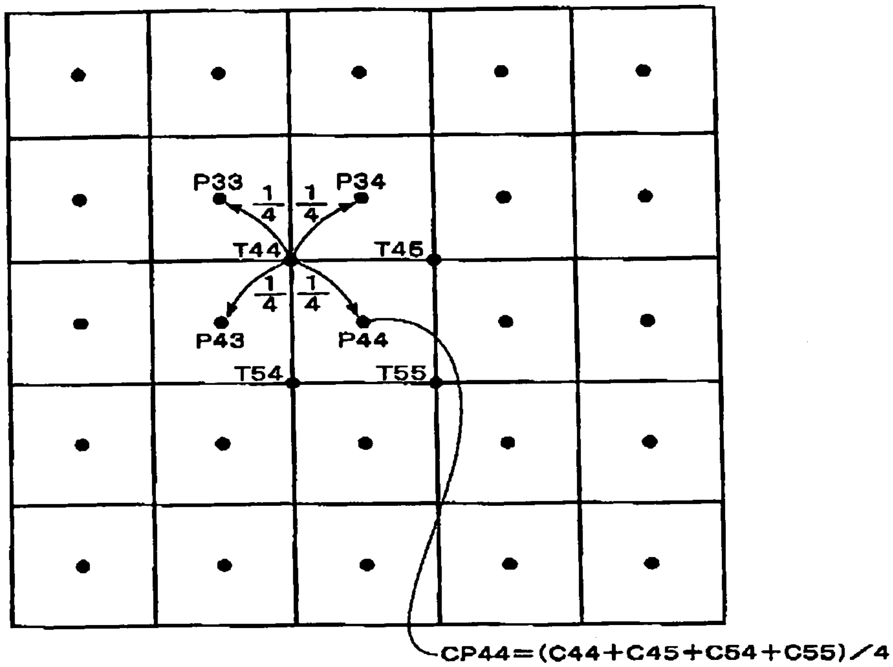
P33
P34
1/4
1/4
T44
T45
1/4
1/4
P43
P44
T54
T55
CP44=(C44+C45+C54+C55)/4

FIG. 31B

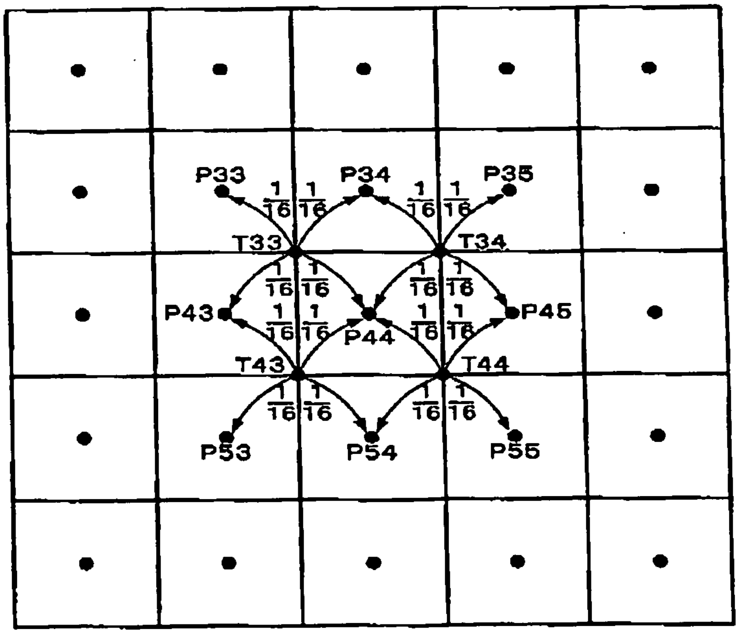
P33
P34
P35
1/16
1/16
1/16
1/16
T33
T34
1/16
1/16
1/16
1/16
P43
P44
P45
1/16
1/16
1/16
1/16
T43
T44
1/16
1/16
1/16
1/16
P53
P54
P55

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FIG. 32A

	1/16	2/16	1/16	
	2/16	4/16	2/16	
	1/16	2/16	1/16	

FIG. 32B

1/256	4/256	6/256	4/256	1/256
4/256	16/256	24/256	16/256	4/256
6/256	24/256	36/256	24/256	6/256
4/256	16/256	24/256	16/256	4/256
1/256	4/256	6/256	4/256	1/256

FIG. 33

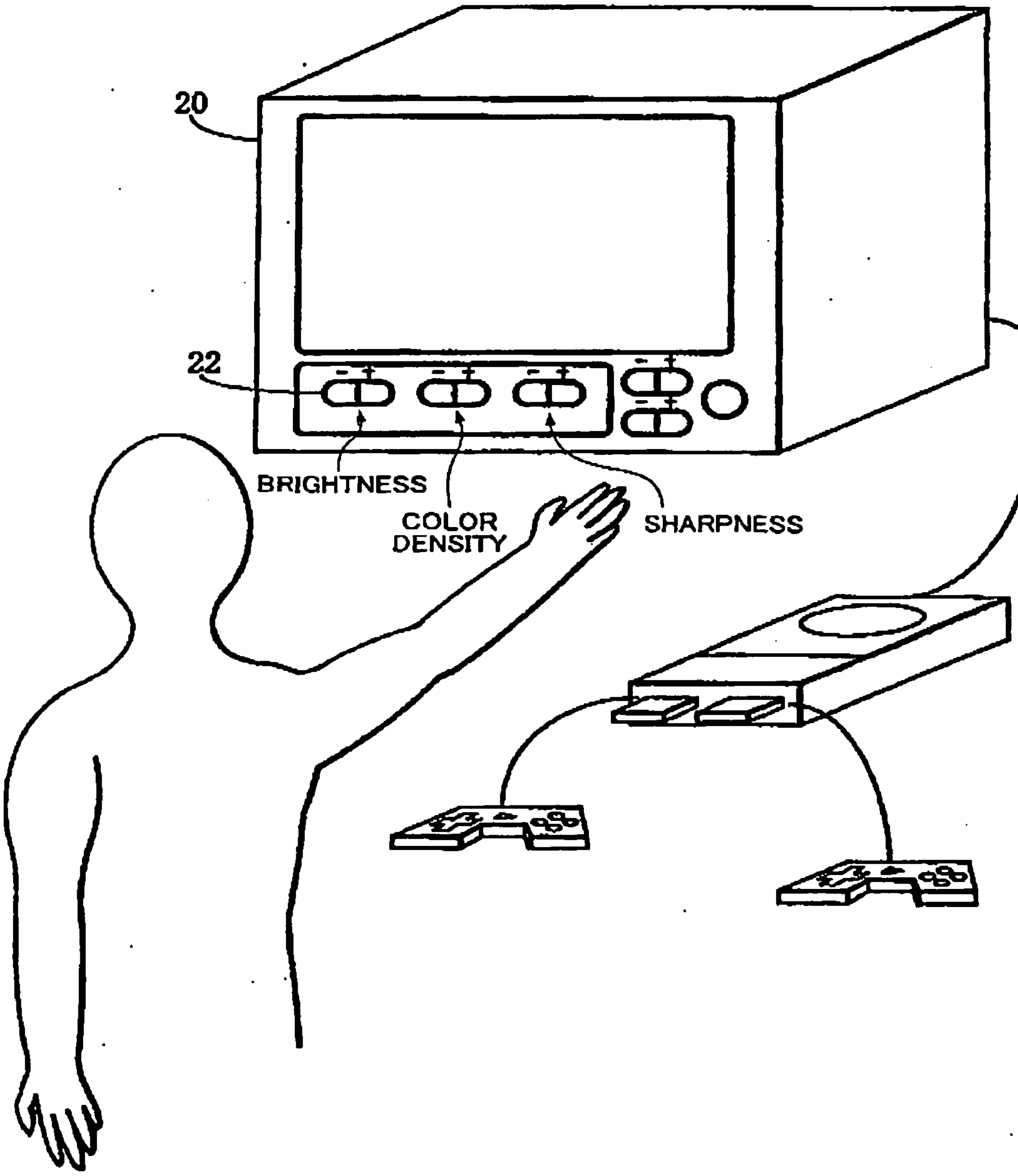
20
22
− +
− +
− +
− +
− +
BRIGHTNESS
COLOR DENSITY
SHARPNESS

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FIG. 34

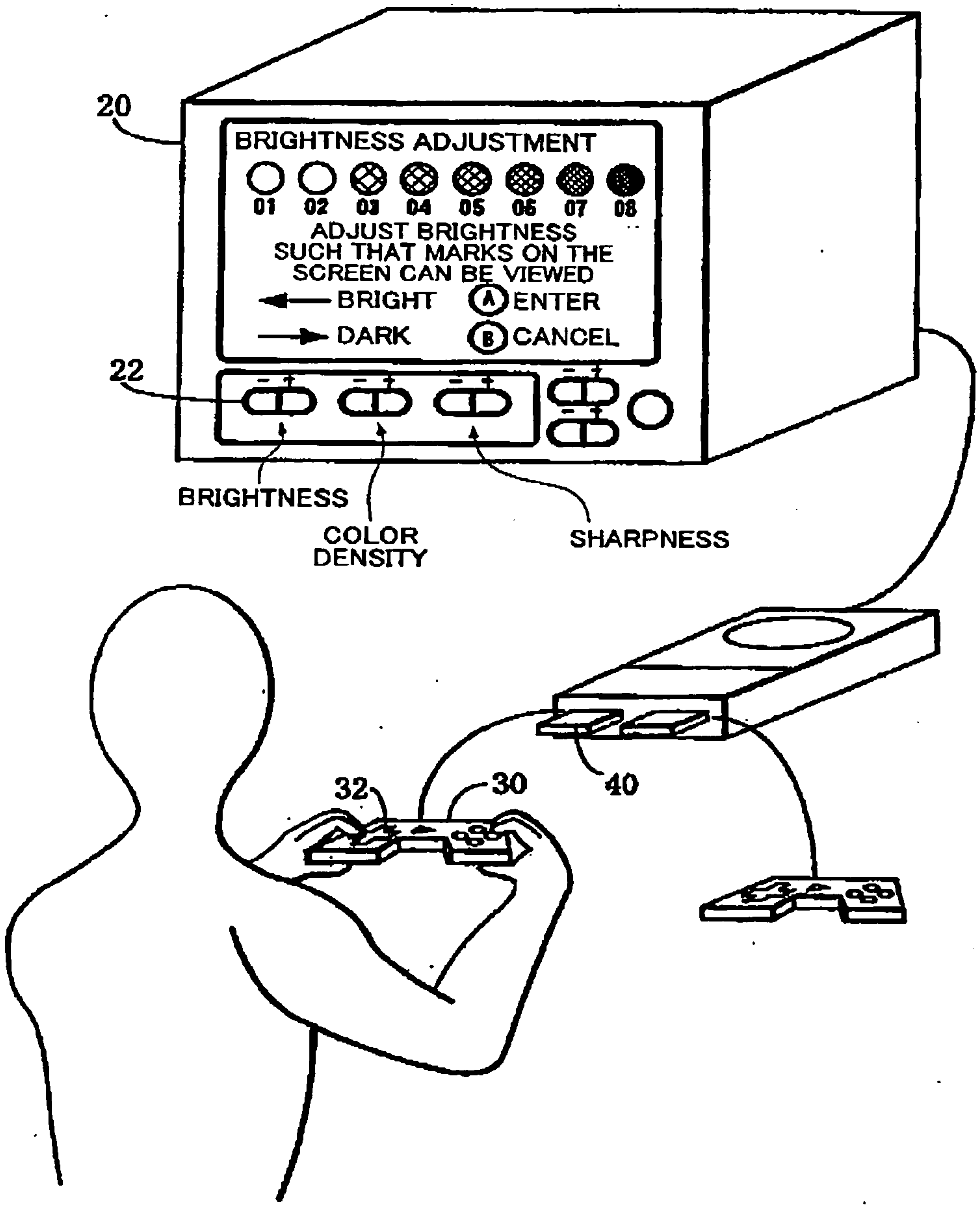
20
BRIGHTNESS ADJUSTMENT
01
02
03
04
05
06
07
08
ADJUST BRIGHTNESS SUCH THAT MARKS ON THE SCREEN CAN BE VIEWED
◀— BRIGHT
—▶ DARK
Ⓐ ENTER
Ⓑ CANCEL
22
BRIGHTNESS
COLOR DENSITY
SHARPNESS
32
30
40

FIG. 35

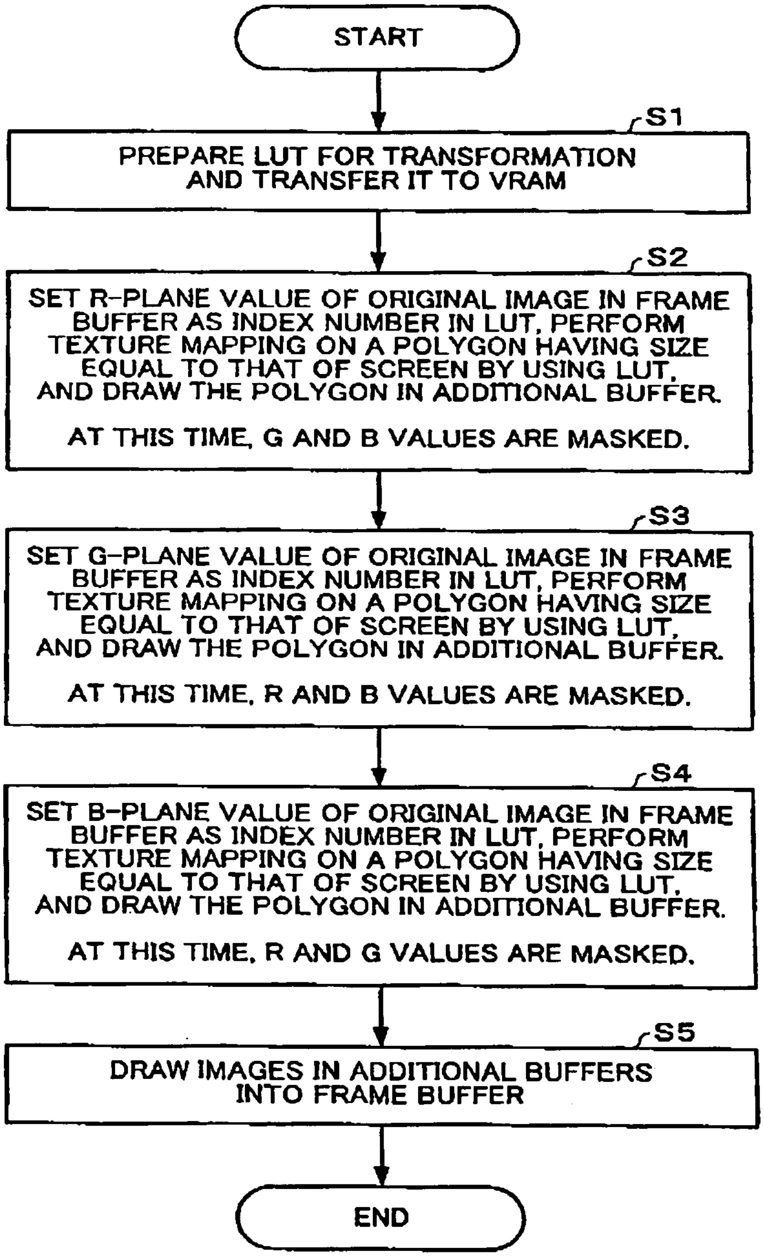
START
S1
PREPARE LUT FOR TRANSFORMATION AND TRANSFER IT TO VRAM
S2
SET R-PLANE VALUE OF ORIGINAL IMAGE IN FRAME BUFFER AS INDEX NUMBER IN LUT, PERFORM TEXTURE MAPPING ON A POLYGON HAVING SIZE EQUAL TO THAT OF SCREEN BY USING LUT, AND DRAW THE POLYGON IN ADDITIONAL BUFFER.
AT THIS TIME, G AND B VALUES ARE MASKED.
S3
SET G-PLANE VALUE OF ORIGINAL IMAGE IN FRAME BUFFER AS INDEX NUMBER IN LUT, PERFORM TEXTURE MAPPING ON A POLYGON HAVING SIZE EQUAL TO THAT OF SCREEN BY USING LUT, AND DRAW THE POLYGON IN ADDITIONAL BUFFER.
AT THIS TIME, R AND B VALUES ARE MASKED.
S4
SET B-PLANE VALUE OF ORIGINAL IMAGE IN FRAME BUFFER AS INDEX NUMBER IN LUT, PERFORM TEXTURE MAPPING ON A POLYGON HAVING SIZE EQUAL TO THAT OF SCREEN BY USING LUT, AND DRAW THE POLYGON IN ADDITIONAL BUFFER.
AT THIS TIME, R AND G VALUES ARE MASKED.
S5
DRAW IMAGES IN ADDITIONAL BUFFERS INTO FRAME BUFFER
END

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FIG. 36

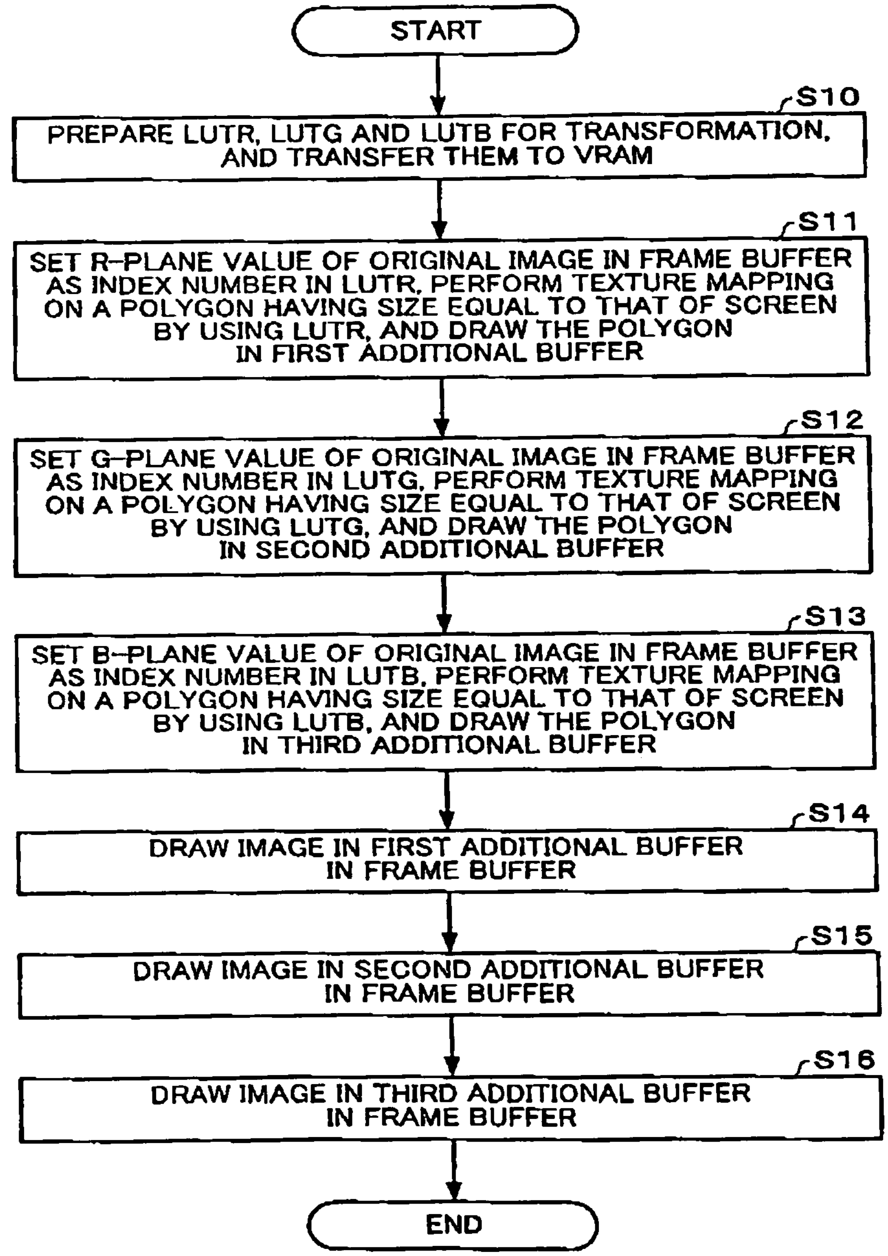
START
S10
PREPARE LUTR, LUTG AND LUTB FOR TRANSFORMATION, AND TRANSFER THEM TO VRAM
S11
SET R-PLANE VALUE OF ORIGINAL IMAGE IN FRAME BUFFER AS INDEX NUMBER IN LUTR, PERFORM TEXTURE MAPPING ON A POLYGON HAVING SIZE EQUAL TO THAT OF SCREEN BY USING LUTR, AND DRAW THE POLYGON IN FIRST ADDITIONAL BUFFER
S12
SET G-PLANE VALUE OF ORIGINAL IMAGE IN FRAME BUFFER AS INDEX NUMBER IN LUTG, PERFORM TEXTURE MAPPING ON A POLYGON HAVING SIZE EQUAL TO THAT OF SCREEN BY USING LUTG, AND DRAW THE POLYGON IN SECOND ADDITIONAL BUFFER
S13
SET B-PLANE VALUE OF ORIGINAL IMAGE IN FRAME BUFFER AS INDEX NUMBER IN LUTB, PERFORM TEXTURE MAPPING ON A POLYGON HAVING SIZE EQUAL TO THAT OF SCREEN BY USING LUTB, AND DRAW THE POLYGON IN THIRD ADDITIONAL BUFFER
S14
DRAW IMAGE IN FIRST ADDITIONAL BUFFER IN FRAME BUFFER
S15
DRAW IMAGE IN SECOND ADDITIONAL BUFFER IN FRAME BUFFER
S16
DRAW IMAGE IN THIRD ADDITIONAL BUFFER IN FRAME BUFFER
END

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FIG. 37

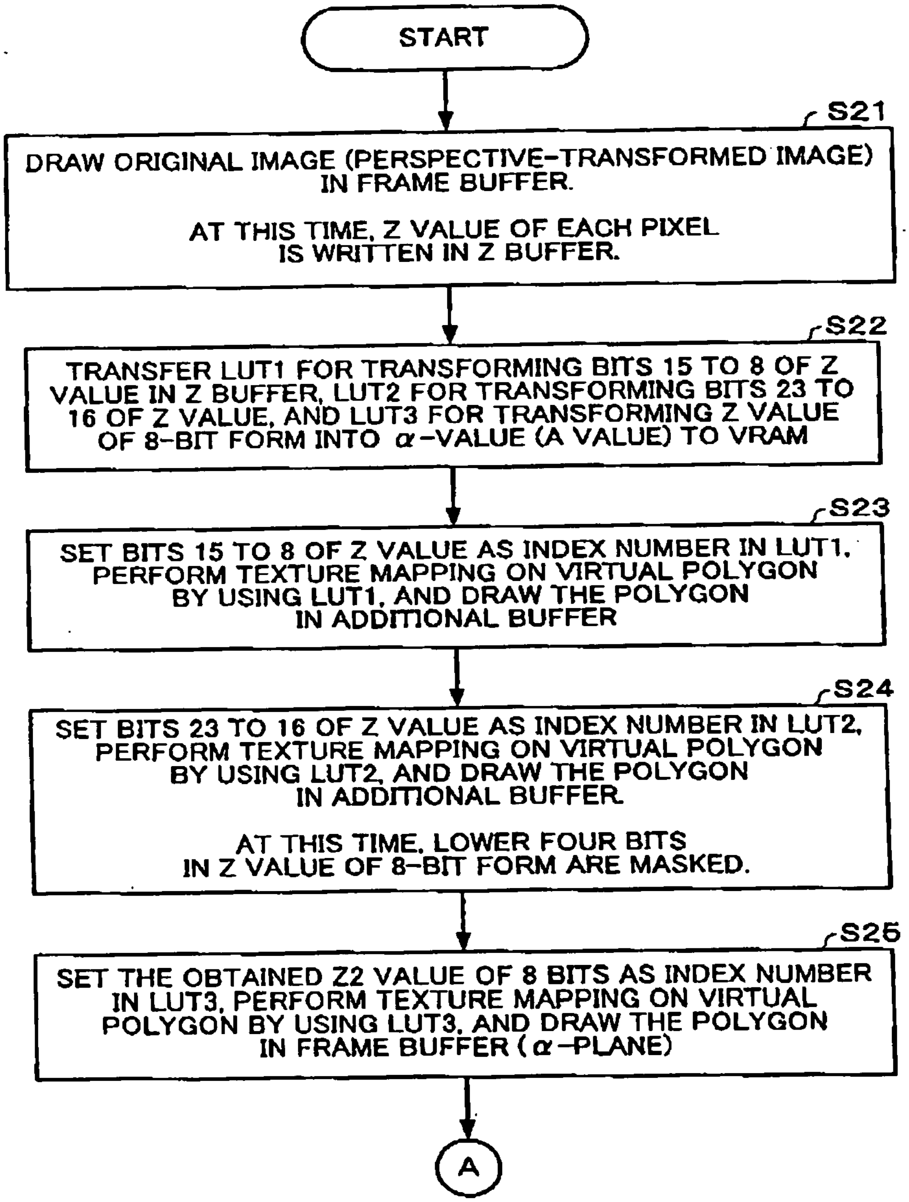
START
S21
DRAW ORIGINAL IMAGE (PERSPECTIVE-TRANSFORMED IMAGE) IN FRAME BUFFER.
AT THIS TIME, Z VALUE OF EACH PIXEL IS WRITTEN IN Z BUFFER.
S22
TRANSFER LUT1 FOR TRANSFORMING BITS 15 TO 8 OF Z VALUE IN Z BUFFER, LUT2 FOR TRANSFORMING BITS 23 TO 16 OF Z VALUE, AND LUT3 FOR TRANSFORMING Z VALUE OF 8-BIT FORM INTO α-VALUE (A VALUE) TO VRAM
S23
SET BITS 15 TO 8 OF Z VALUE AS INDEX NUMBER IN LUT1, PERFORM TEXTURE MAPPING ON VIRTUAL POLYGON BY USING LUT1, AND DRAW THE POLYGON IN ADDITIONAL BUFFER
S24
SET BITS 23 TO 16 OF Z VALUE AS INDEX NUMBER IN LUT2, PERFORM TEXTURE MAPPING ON VIRTUAL POLYGON BY USING LUT2, AND DRAW THE POLYGON IN ADDITIONAL BUFFER.
AT THIS TIME, LOWER FOUR BITS IN Z VALUE OF 8-BIT FORM ARE MASKED.
S25
SET THE OBTAINED Z2 VALUE OF 8 BITS AS INDEX NUMBER IN LUT3, PERFORM TEXTURE MAPPING ON VIRTUAL POLYGON BY USING LUT3, AND DRAW THE POLYGON IN FRAME BUFFER (α-PLANE)
A

FIG. 38

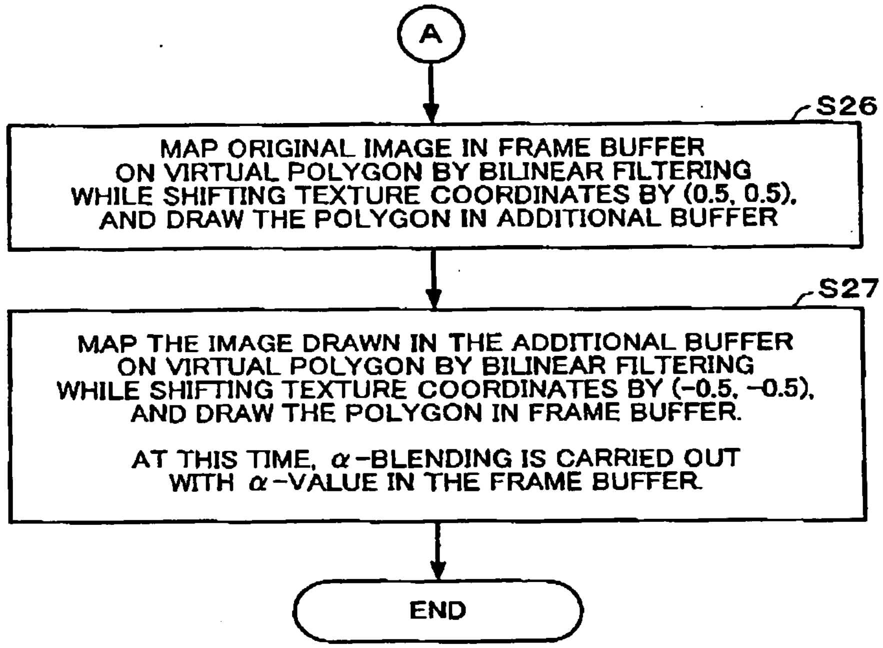
A
S26
MAP ORIGINAL IMAGE IN FRAME BUFFER ON VIRTUAL POLYGON BY BILINEAR FILTERING WHILE SHIFTING TEXTURE COORDINATES BY (0.5, 0.5), AND DRAW THE POLYGON IN ADDITIONAL BUFFER
S27
MAP THE IMAGE DRAWN IN THE ADDITIONAL BUFFER ON VIRTUAL POLYGON BY BILINEAR FILTERING WHILE SHIFTING TEXTURE COORDINATES BY (−0.5, −0.5), AND DRAW THE POLYGON IN FRAME BUFFER.
AT THIS TIME, α-BLENDING IS CARRIED OUT WITH α-VALUE IN THE FRAME BUFFER.
END

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FIG. 39

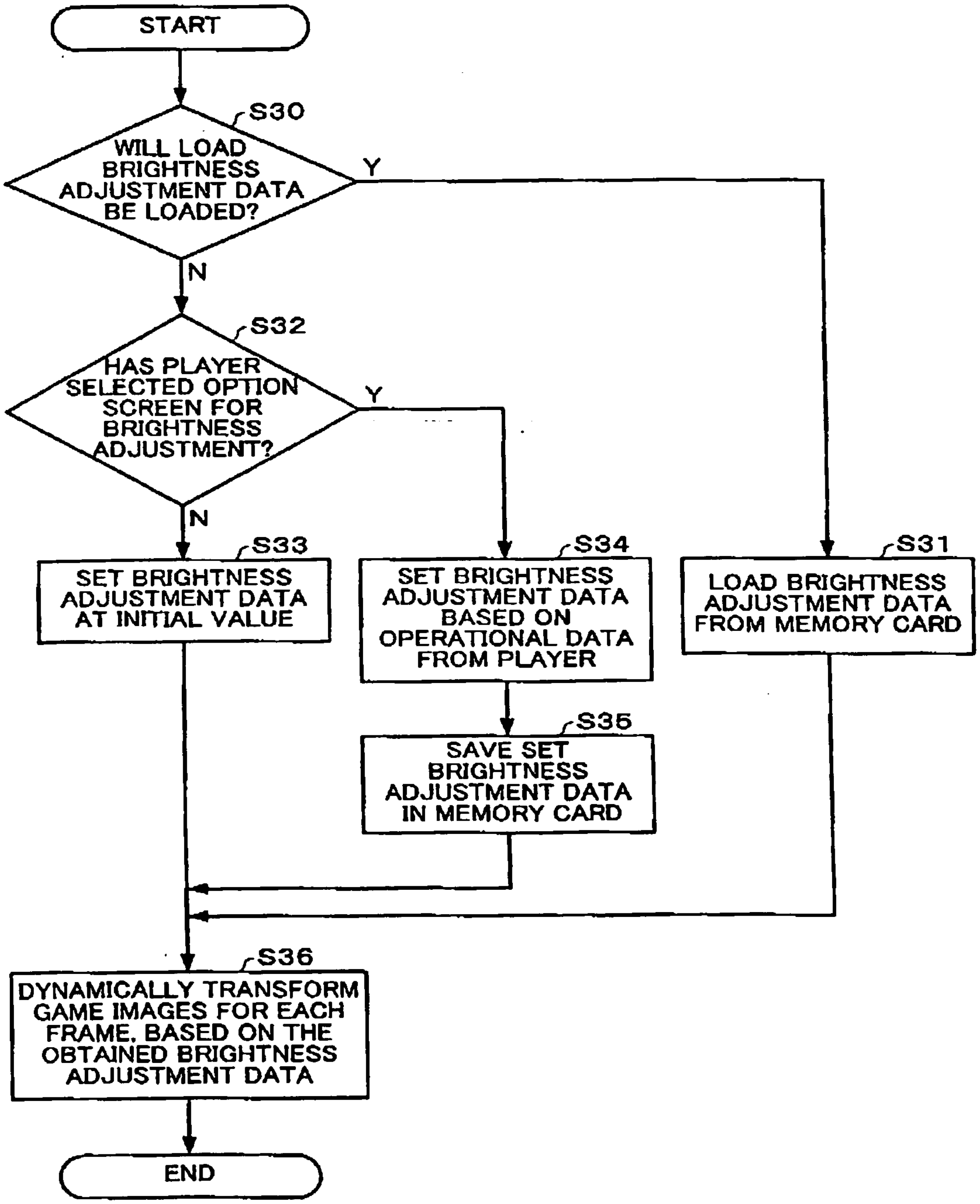
START
S30
WILL LOAD BRIGHTNESS ADJUSTMENT DATA BE LOADED?
Y
N
S32
HAS PLAYER SELECTED OPTION SCREEN FOR BRIGHTNESS ADJUSTMENT?
Y
N
S33
SET BRIGHTNESS ADJUSTMENT DATA AT INITIAL VALUE
S34
SET BRIGHTNESS ADJUSTMENT DATA BASED ON OPERATIONAL DATA FROM PLAYER
S31
LOAD BRIGHTNESS ADJUSTMENT DATA FROM MEMORY CARD
S35
SAVE SET BRIGHTNESS ADJUSTMENT DATA IN MEMORY CARD
S36
DYNAMICALLY TRANSFORM GAME IMAGES FOR EACH FRAME, BASED ON THE OBTAINED BRIGHTNESS ADJUSTMENT DATA
END

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FIG. 40

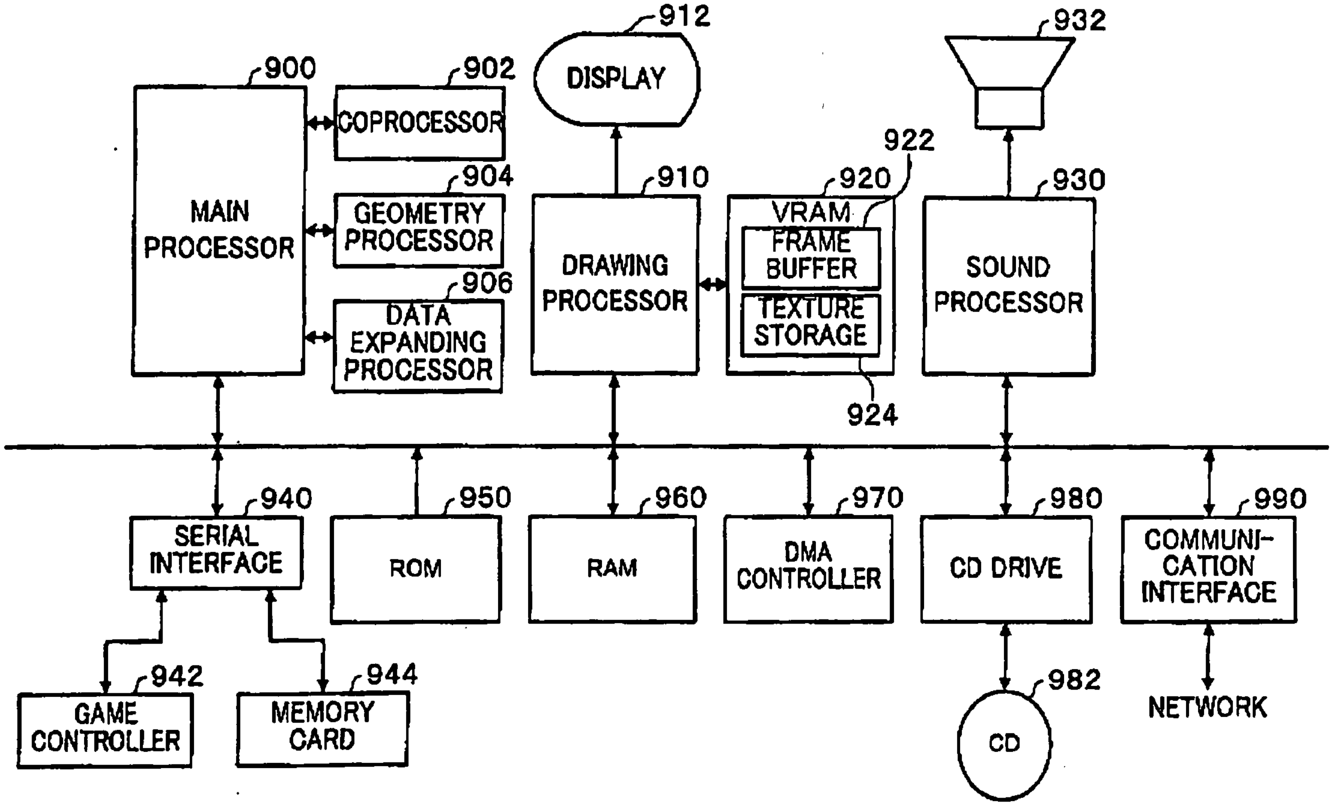
912
DISPLAY
932
900
MAIN PROCESSOR
902
COPROCESSOR
904
GEOMETRY PROCESSOR
906
DATA EXPANDING PROCESSOR
910
DRAWING PROCESSOR
922
920
VRAM
FRAME BUFFER
TEXTURE STORAGE
924
930
SOUND PROCESSOR
940
SERIAL INTERFACE
950
ROM
960
RAM
970
DMA CONTROLLER
980
CD DRIVE
990
COMMUNI-CATION INTERFACE
942
GAME CONTROLLER
944
MEMORY CARD
982
CD
NETWORK

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FIG. 41A

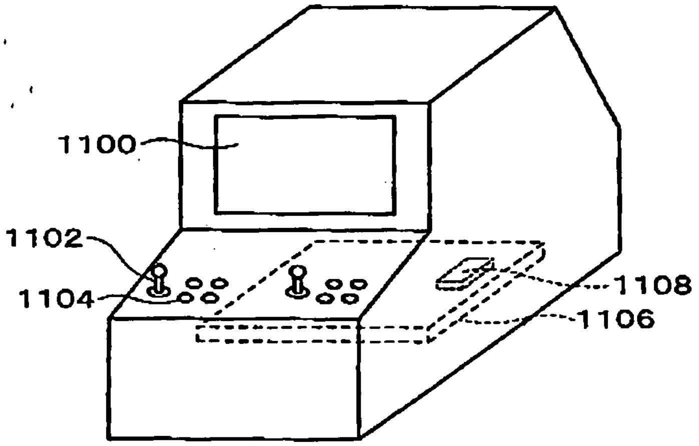

1100
1102
1104
1108
1106

FIG. 41B

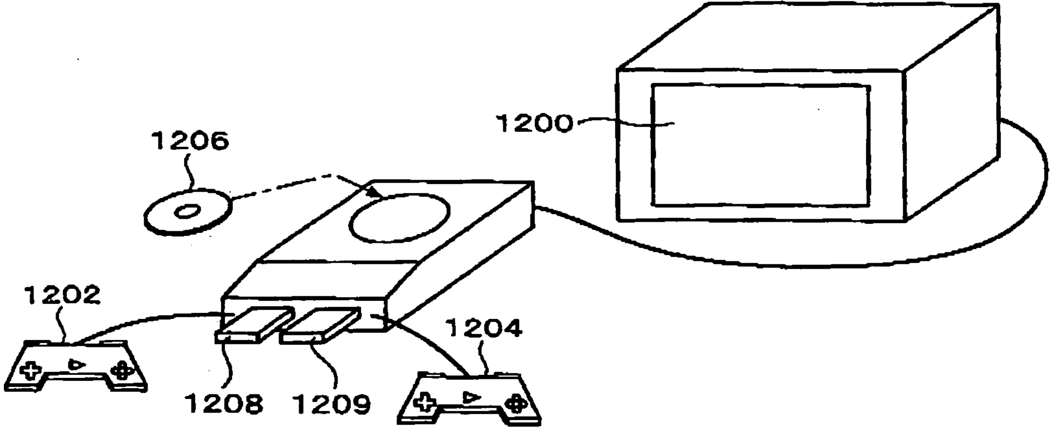
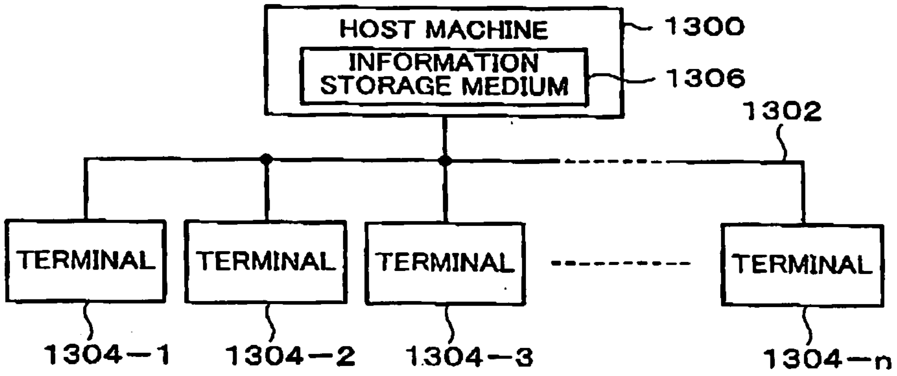

1206
1200
1202
1204
1208
1209

FIG. 41C


HOST MACHINE
INFORMATION STORAGE MEDIUM
1300
1306
1302
TERMINAL
TERMINAL
TERMINAL
TERMINAL
1304-1
1304-2
1304-3
1304-n